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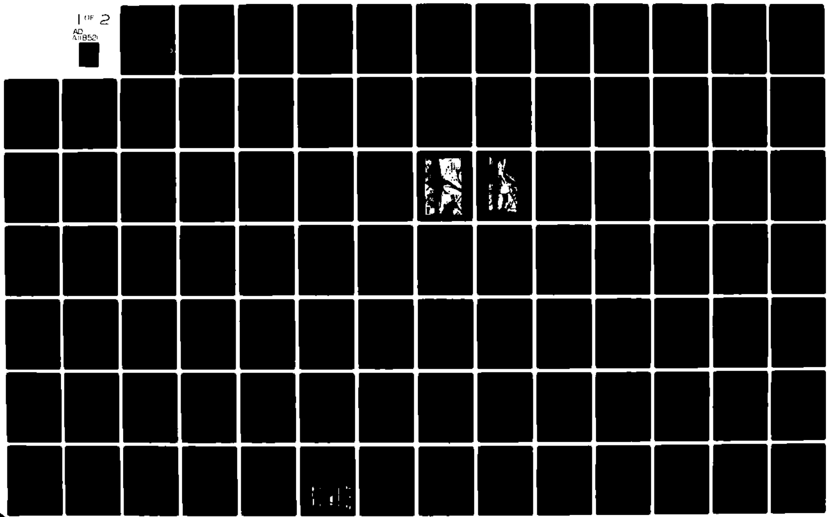

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# ST. LAWRENCE SEAWAY ADDITIONAL LOCKS STUDY

## PRELIMINARY FEASIBILITY REPORT





U.S. Army Engineer District, Buffalo

**JULY 1982**

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| Nonstructural Plans | Locks | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the results of a Preliminary Feasibility Study of the navigation improvements for the St. Lawrence Seaway. The study developed traffic forecasts and commdity movement for the entire Great Lakes/ St. Lawrence Seaway to determine lock capacity at the Eisenhower and Snell Locks, other St. Lawrence River Locks and the Welland Canal. Based on capacity dates structural and nonstructural navigation improvements were evaluated. Costs, benefits and impacts of different capacity improvements were derived.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PRELIMINARY FEASIBILITY REPORT

ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS AND OTHER NAVIGATION IMPROVEMENTS

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## ACKNOWLEDGEMENTS

The contents of this report was developed through efforts of many persons who participated in the study of ways and means to provide improvements to the U.S. portion of the St. Lawrence Seaway. These persons include both Corps and non-Corps personnel.

Corps participants who made significant contributions include:

James Karsten - Study Team Manager, Eastern Basin
Michael Pelone - Study Team Economist, Economics Branch
Philip Frapwell - Study Team Environmentalist, Environmental Branch
Tod Smith - Study Team Sociologist, Environmental Branch
Joseph Erhart - Study Team Designer, Design Branch

All non-Corps participants who made significant contributions cannot be easily defined. For this reason, only their employing agency or firm are identified below:

U.S. Fish and Wildlife Service
St. Lawrence Seaway Development Corporation
St. Lawrence Seaway Authority
New York State Department of Environmental Conservation
New York State Department of Transportation
Booz-Allen and Hamilton, Inc.
ARCTEC, Inc.
TAMS, Inc.
Cornell University, Department of Environmental Resources

The report itself was produced through efforts of many other Corps personnel. All of those who made major contributions are listed below to give deserved credit for their work:

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PRELIMINARY FEASIBILITY REPORT

ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS AND OTHER NAVIGATION IMPROVEMENTS

## INTRODUCTION

The Great Lakes-St. Lawrence Seaway (GL/SLS) system represents the world's largest navigable body of fresh water. This system provides the means to serve the large number of ports along the approximately 8,300 miles of shoreline encompassed by this system. The system serves as a major trade route for the mid-continent of North America, allowing ships from around the world to carry cargoes to and from the industrial and agricultural heartland of both the United States and Canada.

Since the opening of the St. Lawrence River portion of the Seaway system to deep-draft navigation in 1959, the total tonnage transiting the Seaway has shown a long-term upward trend. If this trend continues until the traffic approaches the capacity of the Seaway, substantial delays will be encountered. This is due to physical constraints within the system. Although a great deal of the GL/SLS system is open-water navigation, there are areas such as the connecting channels, the Welland Canal, and St. Lawrence River upstream of Montreal, which involve transit through a series of constricting channels and locks. These constraints, especially the locks, place a limitation on the number and size of vessels which can effectively use the system, thus limiting the capacity of the system. If this system reaches its capacity, additional movements must defer to another mode. This translates to increased transportation rates and subsequently increased costs to the nation.

This study evaluates the Welland Canal, Lake Ontario, and the St. Lawrence River to Montreal. A separate study being conducted by the Corps of Engineers, Detroit District, evaluates the Upper Great Lakes Region which includes Lakes Superior, Michigan, Huron and Erie and their connecting channels. Harbors throughout the two sub-systems will be analyzed and reported on under that study authority. That study is entitled the Great Lakes Connecting Channels and Harbors Study (GLCCHS). For systemwide modifications to become a reality, the two studies will be coordinated closely. Canadian co-participation for system modifications will also be vital.

### STUDY AUTHORITY

On 15 June 1966, at the request of Senator Philip A. Hart of Michigan, the Committee on Public Works of the United States Senate adopted the following resolution authorizing a study of the exiting U. S. development on the St. Lawrence River.

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act approved June 13, 1902 be, and is hereby requested to review the report

of the Chief of Engineers on the St. Lawrence River-Lake Ontario to the Canadian Border, published as House Document Numbered 1591, Sixty-fifth Congress, and other pertinent reports, with a view toward determining whether the existing project for the development of the St. Lawrence Seaway in United States territory, authorized by the Act of May 13, 1954, (Public Law 358, 83rd Congress), should be modified in any way at the present time, with particular reference to determining the adequacy of the existing locks in the Long Sault Canal, and the advisability of their enlargement or augmentation by the construction of additional or duplicate locks, in view of the needs of the present and anticipated heavy volume of commerce utilizing the waterway."

This quoted resolution is the authority for this Preliminary Feasibility Study being conducted by the Buffalo District of the U. S. Army Corps of Engineers.

## SCOPE OF STUDY

### a. Purpose of the Study.

The purpose of the St. Lawrence Seaway-Additional Locks Study is to determine the adequacy of the existing locks and channels in the U. S. section of the St. Lawrence River section of the Seaway in light of present and future needs, and the advisability of their rehabilitation or augmentation.

Since need for the improvement of the U. S. section of the St. Lawrence River is based on the needs of present and future commerce within the Great Lakes hinterland, the major thrust of this investigation is commercial navigation along with its associated benefits and costs; the end being to identify commercial navigation needs and present a full range of alternatives for commercial navigation considering related benefits, costs, and social and environmental implications as they relate to the U. S. section of the St. Lawrence Seaway.

### b. Study Limits.

The U. S. section of the St. Lawrence Seaway is just a small part of the Great Lakes/St. Lawrence Seaway (GL/SLS) system (see Figure 1). The U. S. section consists of the Eisenhower and Snell Locks, the connecting channel (Wiley-Dondero Canal) between those two locks, and the channelized portion of the St. Lawrence River within U. S. territory (see Figure 2). This U.S. portion is totally with the State of New York. In 1979, over 10 percent of the total tonnage of waterborne commerce of the United States moved over the GL/SLS system. Considering the size and amount of commerce transiting the GL/SLS system, any alteration to that system could have considerable impact on users of the system and the economy of the area served by the system. Therefore, any navigation system change along the U. S. portion of the St. Lawrence Seaway requires an evaluation of impacts on the geographic region commercially and economically tributary to the Great Lakes-St. Lawrence River Region. That region will be the study area for purposes

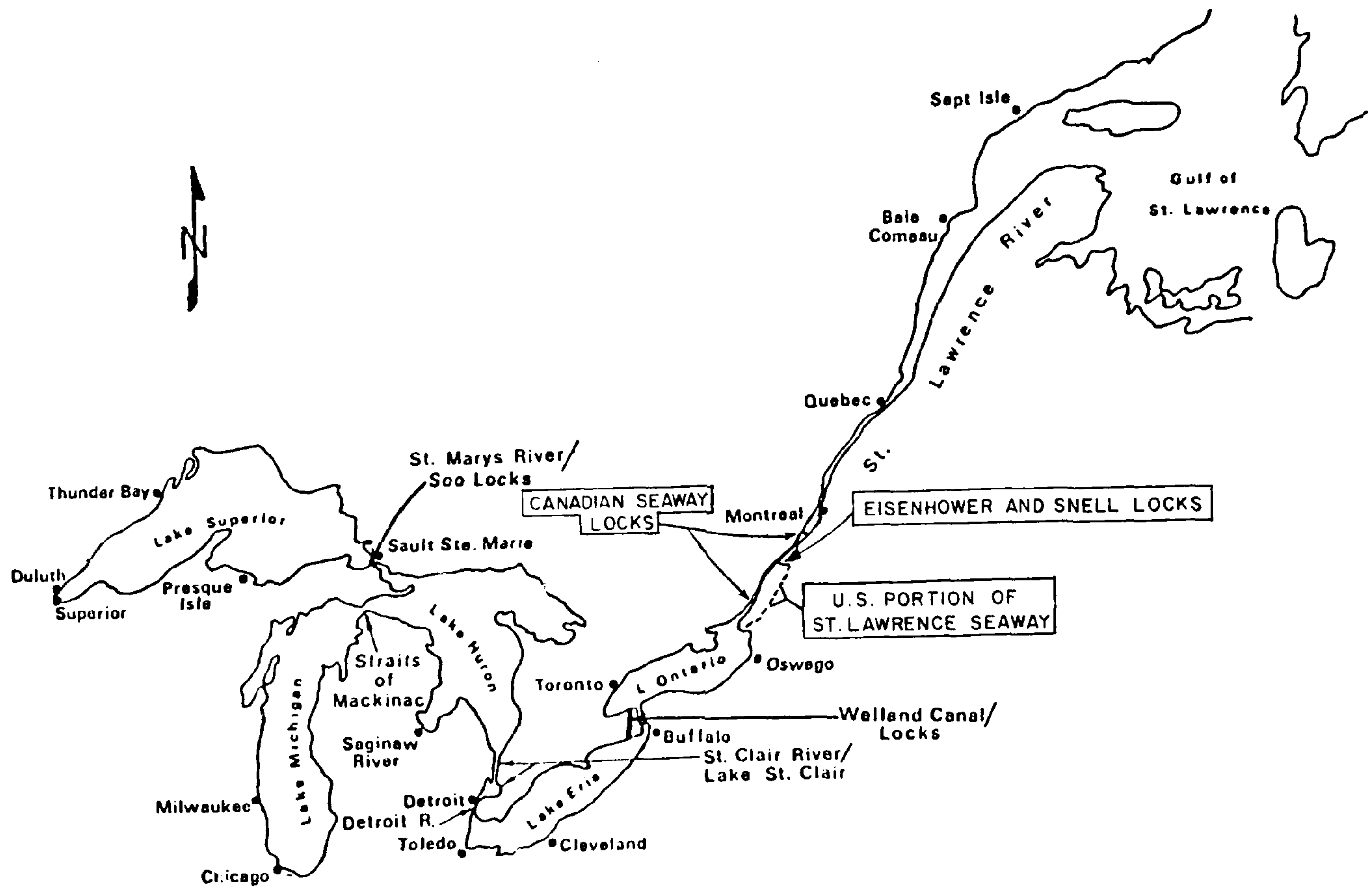



FIGURE 1 THE GREAT LAKES - ST. LAWRENCE SEAWAY SYSTEM

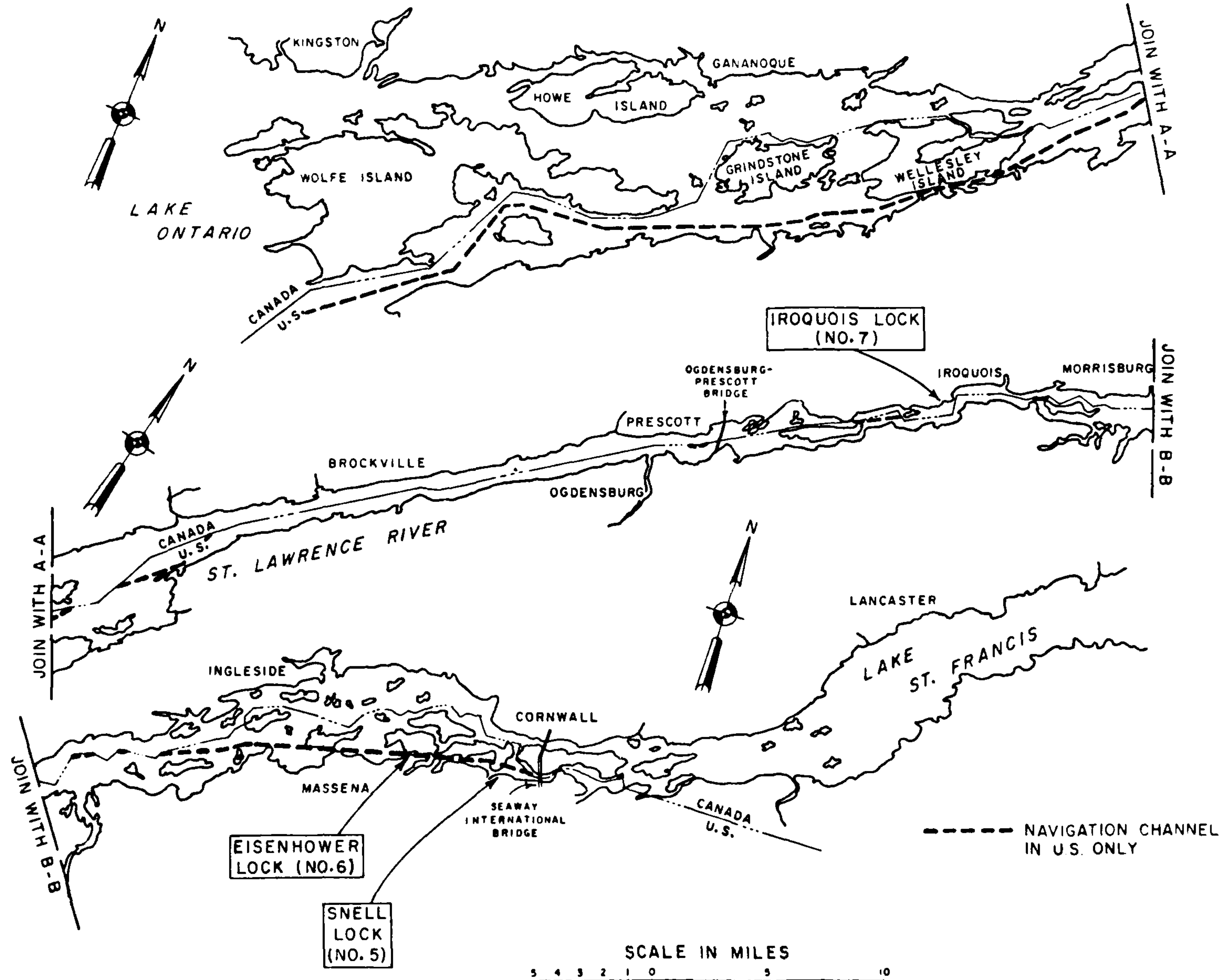

KINGSTON
GANANOQUE
HOWE ISLAND
WOLFE ISLAND
GRINDSTONE ISLAND
WELLESLEY ISLAND
LAKE ONTARIO
CANADA
U.S.
JOIN WITH A-A
N
IROQUOIS LOCK (NO.7)
OGDENSBURG-PRESCOTT BRIDGE
IROQUOIS
MORRISBURG
PRESCOTT
BROCKVILLE
OGDENSBURG
ST. LAWRENCE RIVER
JOIN WITH B-B
LANCASTER
LAKE ST. FRANCIS
INGLESIDE
CORNWALL
MASSENA
SEAWAY INTERNATIONAL BRIDGE
EISENHOWER LOCK (NO.6)
SNELL LOCK (NO.5)
NAVIGATION CHANNEL IN U.S. ONLY
SCALE IN MILES
5 4 3 2 1 0 5 10

FIGURE 2

of this study, and it includes the eight States bordering the GL/SLS system and 11 contiguous States known as the hinterland (see Figure 3).

The impacts of any navigation plan will be either national, regional, or local or a combination thereof. The national impact area is self-explanatory, and the regional impact area will be the study area as defined above. The local impact area is a subpart of the study area where local or site-specific physical improvements or operation changes may occur and will in the future be referred to as the Possible Improvement Area. That area is limited generally by the confines of the U. S. portion of the St. Lawrence Seaway for purposes of this study, and is totally within New York State and the counties of Jefferson and St. Lawrence. Major municipalities within that area include Cape Vincent, Clayton, and Alexandria Bay in Jefferson County and Morristown, Ogdensburg, Waddington, and Massena in St. Lawrence County.

c. Limits Relating to Canada.

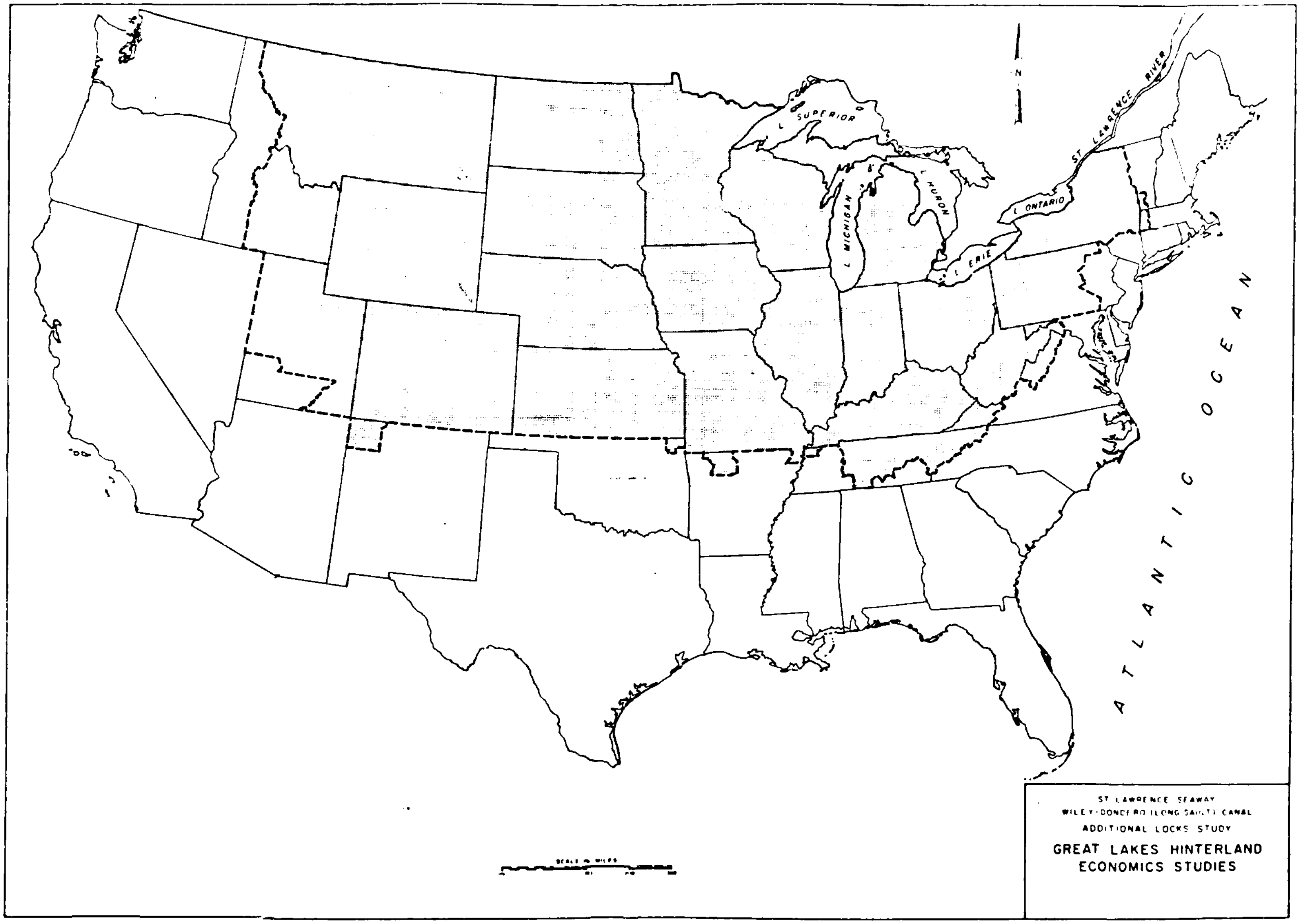
The scope of the study is directed solely towards a U. S. plan for navigation improvements and to U. S. benefits accruing from navigation improvements. This limitation of the authorization recognizes the international character of the Great Lakes/St. Lawrence Seaway system and the need for Canadian coordination and co-participation in implementing a systemwide navigation improvement project. The study considers all known Canadian plans for navigation projects that would affect U. S. proposals. It is not within the scope of this study to include a Canadian plan of improvement, or to determine Canadian benefits and costs.

## STUDY PARTICIPANTS AND COORDINATION

The Corps of Engineers was directed by the U. S. Congress to make this investigation. Buffalo District carried out this investigation for Congress. A Buffalo District study team, an interdisciplinary staff group including a study manager, a terrestrial biologist, an aquatic biologist, a sociologist, an archeologist, a navigation economist, and several civil and design engineers performed or directed this effort. The U. S. Fish and Wildlife Service (USFWS), Cortland office, and two Contractors were also key participants in this study. The USFWS conducted two biological surveys. Booz-Allen and Hamilton, Inc., and Arctec, Inc., under contract, conducted an economic analysis with a preliminary assessment of benefits and costs of alternative navigation capacity improvements.

The Detroit District and North Central Division, Corps of Engineers participated in this study by providing information and by acting as additional sources of expertise for GL/SLS systemwide economic studies of capacity. Also close coordination was maintained between Buffalo District, Detroit District and North Central Division to insure development of compatible subsystem improvement plans to be used in this and the GLCCH study.

Intensive coordination was also maintained throughout Stage 2 studies with the St. Lawrence Seaway Development Corporation. A number of coordination meetings along with the free exchange of information provided a good basis



ST LAWRENCE SEAWAY
WILEY-DONDERO (LONG SAULT) CANAL
ADDITIONAL LOCKS STUDY
GREAT LAKES HINTERLAND
ECONOMICS STUDIES
ATLANTIC OCEAN
ST LAWRENCE RIVER
L ONTARIO
L ERIE
L HURON
L MICHIGAN
L SUPERIOR
N
SCALE IN MILES


FIGURE 3

for the analyses performed. Through them informal coordination with their Canadian counterpart, the St. Lawrence Seaway Authority, was possible which provided an important link between this study and future Canadian plans.

This study has been coordinated with various International, Federal, State, regional, and local agencies, organizations, and the general public. Primary coordination efforts have been with International, Federal, State, and local agencies. In May 1980, an interagency coordinating meeting was held with representatives from:

U. S. Fish and Wildlife Service
Wayne County, NY
New York State Department of Environmental Conservation
Power Authority of the State of New York
Monroe County, NY
New York State Office of Parks and Recreation
St. Lawrence Seaway Development Corporation
New York State Department of Public Services
Orleans County, NY
U. S. Geological Survey
Jefferson County, NY
Black River - St. Lawrence Regional Planning Board
U. S. Soil Conservation Service
New York State Department of Agriculture and Markets
St. Lawrence County, NY
New York State Department of State - CZM
Niagara County, NY

Additionally, several informal meetings regarding this study and the GLCCH Study have been conducted with New York State Department of Environmental Conservation, St. Lawrence Seaway Development Corporation, U. S. Fish and Wildlife Service, and members of the Great Lakes Commission.

## PRIOR AND ONGOING STUDIES, REPORTS, AND IMPROVEMENTS

This section will cover only those works which represent important sources of input to this study. Many reports and studies have been prepared on subjects dealing with the study area and a more exhaustive listing can be found in Appendix G - BIBLIOGRAPHY.

### a. Corps

The large number of U. S. Army Corps of Engineers studies and reports presented here are further broken down into three catagories: (1) Specific - those produced specifically as a part of this study; (2) Systemwide - those produced for the GL/SLS system, a part of which is covered by this study; and (3) Other Studies. Some of these listings under the specific category were done in conjunction with this study's sister study, the Great Lakes Connecting Channels and Harbors Study. Full coordination between these studies has taken palce, as together these studies cover the entire GL/SLS system.

(1) Specific

St. Lawrence Seaway Additional Locks Study, Geotechnical Report (1981) - This report was prepared by Tippetts-Abbott-McCarthy-Straton Engineers, Architects, and Planners for Buffalo District. The report provided geotechnical data obtained for the current investigation on the regional geology, local geology, and subsurface explorations. The report concluded that construction of alternative locks and channels at certain locations appeared geotechnically feasible. The report findings are the basis for geotechnical design criteria in this current study.

Biological Survey Along the St. Lawrence River for the St. Lawrence Seaway Additional Locks and Other Navigation Improvements Study (1979) - This report provides the results of a USF&WS biological survey which focused on the area around the Eisenhower and Snell Locks with some coverage upriver on the St. Lawrence. The survey covered benthos, mammals, fish, birds, amphibians, reptiles, and vegetation. This report provided part of the framework used in determining the impacts of alternatives developed for this current study.

Great Lakes/St. Lawrence Regional Transportation Study (1981) - This study was completed for the Corps by Booz-Allen-Hamilton, Inc., and Arctec, Inc. The objective of the GL/SLS Regional Transportation Study was to develop an up-to-date, working analytical tool for economic analysis of GL/SLS transportation system improvements. The study was organized in two phases. Phase I was concerned with the supply and demand for transportation service, the cost of system improvement, the benefits of system improvement, and resulted in the following reports:

- General Description GL/SLS Physical System - This report is a compilation of data which describes the physical and operational characteristics of the locks, connecting channels and harbors which comprise the system.

- GL/SLS Fleet Mix - This report describes the current fleet and develops an estimate of the future fleet based on predictions of commodity demand, retirement rates, and fleet building trends.

- Update of the Maximum Ship Size Study Costs to January 1981 - Construction and maintenance costs of alternative system improvements developed in 1977 are updated in this report. The regional transportation study used that data as a basis for cost estimates.

- Evaluation of Lock Capacity Models for Use in the GL/SLS Regional Transportation Study - In this report, 12 lock capacity models are evaluated and the Corps Lock Capacity Model is selected as the preferred model for use in this study.

- GL/SLS Lock System Performance and Alternatives for Increasing Capacity - This report describes locking procedures at each lock system, identifies operational problems, and identifies structural and nonstructural techniques for increasing lock capacity.

. Sensitivity and Feasibility Analysis of GL/SLS Capacity Expansion Measures to the Year 2050 - This report describes calibration of the lock capacity model and use of the model to evaluate the effectiveness of various capacity expansion scenarios. Complete documentation of the capacity simulation results for various alternatives used in the feasibility analysis is provided.

. Documentation of the Lock Capacity Model Used in the Feasibility Analysis of GL/SLS Capacity Expansion Measures to the Year 2050 - This report contains the documentation of the computer model to determine when lock capacity is reached for the Soo, Welland, and St. Lawrence River Lock systems.

. GL/SLS Regional Transportation Study - A summary report and a preliminary assessment of the life-cycle benefits and costs of alternative capacity improvements to the system were evaluated using discounted cash flow techniques.

. The Competitive Position of the Great Lakes for Containerized Cargo - This report summarizes historical trends in general cargo shipping on the Great Lakes, and evaluates the potential for future general cargo shipping in terms of shipper requirements and carrier operating costs.

. Great Lakes Area Industries - Separate write-ups were prepared for the grain and steel industries and for the industries which are major coal consumers in the Great Lakes area. These write-ups identify trends and the outlook for production and consumption of the major commodities shipped via the lakes, locate major plants, and analyze commodity distribution systems.

. Commodity Flow Forecasts - Traffic forecasts were developed for a base year of 1978 and extended to the year 2050. The forecasts contain detail for 15 commodities. The forecasts of U. S. trade (including domestic, Canadian, and overseas) identify U. S. shipping and/or receiving port. Canadian trade is identified by lock system and direction. High and low scenarios were developed for potentially volatile commodities.

. Analysis of Freight Rates - A file of freight rate information was developed for the major commodity movements using the Great Lakes system. Rail, truck, barge, laker, and ocean rates were collected in order to identify total transportation costs for current Great Lakes routes and for the least expensive alternatives. These rates are the basis for estimation of rate savings benefits of system improvements.

Phase II of the regional transportation study consisted of an assessment of impacts of alternative improvements. The resulting Phase II report is:

. Regional Impacts Study - This report was prepared to evaluate candidate plans of improvement developed during Phase I studies in terms of regional economic, social, intermedial and energy use impacts. Individual plans are ranked in terms of the type and degree of impact and the results displayed within a summary matrix. Plans which maximize their contribution

to or minimize their impacts upon the regional impact criteria are identified.

Maximum Ship Size Study (1977) - The report for this study was completed by North Central Division, Corps of Engineers. The study screened vessels and improvement alternatives for use in the Great Lakes Connecting Channels and Harbors Study and this study. The study served as the cornerstone for forecasts of the number of vessels, freight rates, and commodity data which was further developed by the later Great Lakes/St. Lawrence Seaway Regional Transportation Study.

St. Lawrence Seaway Additional Locks - Recreational Boating Impacts (1982) - This report, prepared for the Corps by Cornell University, presents a qualitative evaluation of recreational navigation problems and potential economic impacts of alternative plans of improvement within the St. Lawrence River area.

St. Lawrence Seaway Additional Locks and Other Navigation Improvements, Plan of Study (1979) - This report is the forerunner to the current study and outlines the current study approach and the necessary studies to be carried out in Stage 2. It also confirmed that there is Federal interest in considering navigation improvements within the U.S. portion of the St. Lawrence River.

(2) Systemwide

Great Lakes Connecting Channels and Harbors Study - This is an ongoing study being conducted by Detroit District, Corps of Engineers, to determine the engineering, economic, environmental, and social feasibility of providing needed navigation channel, harbor, and lock improvements on those channels connecting the upper four Great Lakes. The Great Lakes Connecting Channels and Harbor Study (GLCCHS) is being conducted in close coordination with the St. Lawrence Additional Locks Study because of the possible impacts of one upon the other and their relationship as part of the total GL/SLS system. The Connecting Channels Study is in Stage 2, the same stage as this current study. A Plan of Study was published in 1978.

Lake Erie - Lake Ontario Waterway (1973) - This report by Buffalo District published the results of a feasibility study of constructing an all-American waterway connecting Lake Erie and Lake Ontario. The report included a plan for five locks and channels to accommodate vessels up to 1,000 feet long and a 105-foot beam. No plan was found to be economically feasible based solely on U.S. benefits.

Final Survey Study for Great Lakes and St. Lawrence Seaway Navigation Season Extension (1979) - This report by Detroit District presents the results of the evaluation of six proposals, considering various season lengths and geographic coverages, to further extend the navigation season on the entire GL/SLS system. The conclusion was that season extension is engineeringly and economically feasible up to 10 months on the International Section of the St. Lawrence River. It also made recommendations to extend the navigation season on other parts of the system. The report further

recommended incrementally advancing toward the longest feasible navigation season.

All-American Navigation System Connecting the Great Lakes to the Eastern Seaboard (1979) - A preliminary reconnaissance level report concluded that a new deep draft navigation system connecting the Great Lakes with the Atlantic Ocean is not economically justifiable. The study is continuing investigation of shallow draft navigation feasibility.

(3) Other Related Studies

Ogdensburg Harbor, NY (1982) - This report by Buffalo District discusses plans of improvement for the commercial navigation channel at Ogdensburg Harbor to achieve safe and efficient navigation conditions and safe and efficient loading, unloading, and storage conditions at the Harbor Terminal. Ogdensburg is located within the U. S. Section of the seaway.

Lake Ontario-St. Lawrence River Shoreline Protection Study - This is an ongoing study being conducted by the Buffalo District, which is investigating measures for shoreline protection along Lake Ontario and the St. Lawrence River. This study could provide some base data on the physical and social environment for use in the St. Lawrence Additional Locks Study. A reconnaissance level report was published in 1981 which covered the Lake Ontario shoreline only. Additional authority has also expanded this study to examine shoreline protection for the St. Lawrence River which will be the next major effort on the study.

b. Others.

Polly's Gut Navigation Improvement - In the mid-1970's, a study of navigation problems in the South Cornwall Channel just downstream of Snell Lock at Polly's Gut was performed. As the result of a 1976 Corps study, a navigation problem was evaluated relating to a strong cross current. The problem was resolved when the St. Lawrence Seaway Development Corporation, using funding from the Power Authority for the State of New York (PASNY) and Ontario Hydro, constructed an extension of an existing spur dike in 1976.

Lake Erie Water Level Study (1981) - The International Joint Commission completed a study and report on the feasibility of limited regulation of Lake Erie. The study considered effects of limited regulation on commercial navigation within the GL/SLS system and other parameters. The study concluded that economic losses exceeded the benefits from limited regulation of Lake Erie.

Eisenhower and Snell Locks (1981) - This report was prepared by Harza Engineering for the St. Lawrence Seaway Development Corporation. The purpose of the report was to identify deficiencies in lock design or maintenance. The report cited items of repair that were needed immediately, required, or recommended. Generally, the structural integrity of the locks was found to be sound.

St. Lawrence River Navigation - Aid System Study (1978) This report was prepared by Arctec, Inc. for the U. S. Department of Transportation. The report presented requirements for a navigation guidance system which would increase ship processing capacity on the St. Lawrence Seaway. A computer model was developed to compute capacity as a function of the guidance system. The report concluded that the capacity of the Seaway could be increased by up to 30 percent through use of a guidance system.

Expansion of the St. Lawrence Seaway Facilities (1967) - St. Lawrence Seaway Authority of Canada conducted this study of the feasibility of improvements for navigation at the Welland Canal and St. Lawrence River in the late 1960's. One consequence of the study was the development of the Welland bypass. Additionally, the study considered new locks and channels at the Welland and on the St. Lawrence River to accommodate 1,000-footers. Some of the information presented in this study, although not formalized, was used to develop a Canadian posture towards Seaway improvements.

Seaway Commodity Flow Forecast (1982) - The St. Lawrence Seaway Authority of Canada and the St. Lawrence Seaway Development Corporation of the United States jointly funded this study. Its purpose was to project the potential commodity flows for the St. Lawrence Seaway from the present out to the year 2000.

## THE REPORT AND STUDY PROCESS

This study utilizes the multiobjective planning process established by the Office of the Chief of Engineers, U. S. Army Corps of Engineers. The multiobjective planning process is shown in Figure 4. The process involves three stages of plan development: development of a Reconnaissance study (formerly Plan of Study); development of intermediate plans; and development of detailed plans utilizing the four functional planning tasks of problem identification, formulation of alternatives, impact assessment, and evaluation. Each stage places emphasis on the different planning tasks with a number of iterations of each task occurring during any one stage.

The results of each stage of the planning process are documented and presented in a report format at the end of each stage. These reports, or summaries of these reports, are furnished to the public and other agencies for review and comment.

The first report, the St. Lawrence Seaway - Additional Locks and Other Navigation Improvements Plan of Study, was published in 1979 and contained the results of Stage 1 or the reconnaissance study. That report set forth the justification for this current study. It also established the basis for managing this current study.

This report presents the results of Stage 2 planning and further develops the efforts taken in Stage 1. This Preliminary Feasibility Report is arranged into a Main Report and seven appendices. The Main Report contains a summary of items covered during the study and highlights the areas of particular importance to the study. Also, the Main Report provides the District's

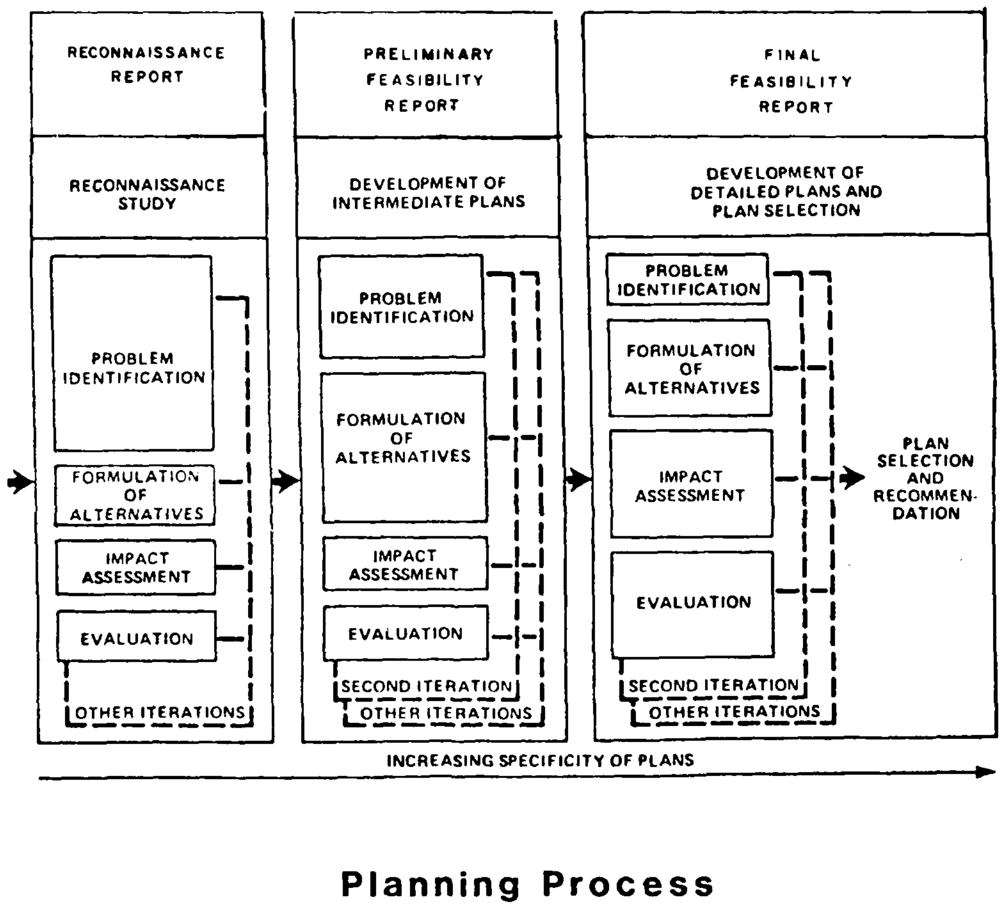



FIGURE 4 PLANNING PROCESS

recommendation regarding further detailed Stage 3 study under the Congressional Resolution.

The seven appendices to this report present supporting data and details covering the features of this Preliminary Feasibility Report. Appendices A through D will be of primary interest to the technical reviewer. Further detailed technical data is also found in the reports cited in the Bibliography, Appendix G.

It is important to note that because of the international character of this study, and the importance of this transportation networks to the U.S., there are some intangible benefits which to do fall within the bounds of the traditional Corps analysis presented in this report. These areas can be described as follows:

a. National Defense,

b. Redundancy or backup to existing locks,

c. Maintenance of a U.S. interest in the Seaway, and

d. The availability of alternate transportation options to both countries (i.e., other transportation networks may not have the capacity or capability of handling the volume of commodities this study is dealing with).

These concepts will be discussed in a very qualitative fashion because the tools to evaluate them are lacking in the planning process used for this study.

## PROBLEM IDENTIFICATION

### EXISTING CONDITIONS

a. Navigation System.

The Great Lakes/St. Lawrence Seaway (GL/SLS) navigation system provides a shipping link between the deep water of the Atlantic Ocean and ports up to 2,400 miles inland on the North American continent. The navigable portion of the system includes: 1,000 statute miles down the St. Lawrence River, 1,350 miles over the five Great Lakes, and 400 miles in connecting channels and waterways. Figure 5 depicts the system and shows its components. Over that distance, a series of locks combine to compensate for the 602-foot elevation difference between Lake Superior and the Gulf of St. Lawrence. Figure 6 is a schematic cross section of the system. For purposes of this study, the GL/SLS system is broken down into the Upper and Lower portions. The Upper portion of the GL/SLS system is defined as: Lakes Superior, Michigan, Huron, and Erie; their connecting channels; the Soo locks complex; and the major harbors on those lakes. The Lower portion of the GL/SLS system is defined as: the Welland Canal, Lake Ontario, the St. Lawrence River and locks, and the harbors within these areas. Figure 5 shows this division. The Lower portion or the GL/SLS is the study area; however, the Upper portion of the system is described in this section to give the reader a picture of the entire GL/SLS system and the interaction of its components. The following is a general description of the system broken down into components: locks, channels, harbors, and fleet mix. Additional information regarding the physical system is available in the 1981 report entitled, General Description of the GL/SLS System - Physical System, by ARCTEC, Inc.

(1) Locks

The locks will be described by lock nodes: the Soo locks, the Welland Canal, and the St. Lawrence River locks. At the end of this description of lock nodes is a brief description of the locking process itself as it would apply to any lock in this system.

Soo Locks - The Soo Locks are located in the St. Marys River between Lake Superior and Lake Huron at Sault Ste. Marie, MI. This lock node is made up of four parallel locks; the MacArthur, Poe, Davis, and Sabin, as illustrated on Figure 7. In addition to these four American owned and operated locks, there is an older lock located on the Canadian side of the river. Table 1 shows the physical characteristics of each of the five locks.

The MacArthur lock handles most loaded ships up to 730 feet long (767 feet with special handling) and 75 feet wide. The Sabin and Davis locks handle most ballasted ships up to 826 feet long and 75 feet wide. The Poe Lock handles any ship which cannot fit in the Sabin, Davis, or MacArthur Locks, up to the maximum size of 1,000 feet long (1,100 feet with special handling) and 105 feet wide, and any smaller vessel on a first-come, first-served basis. The Canadian lock can handle the majority of the pleasure craft and small vessels with shallow drafts.

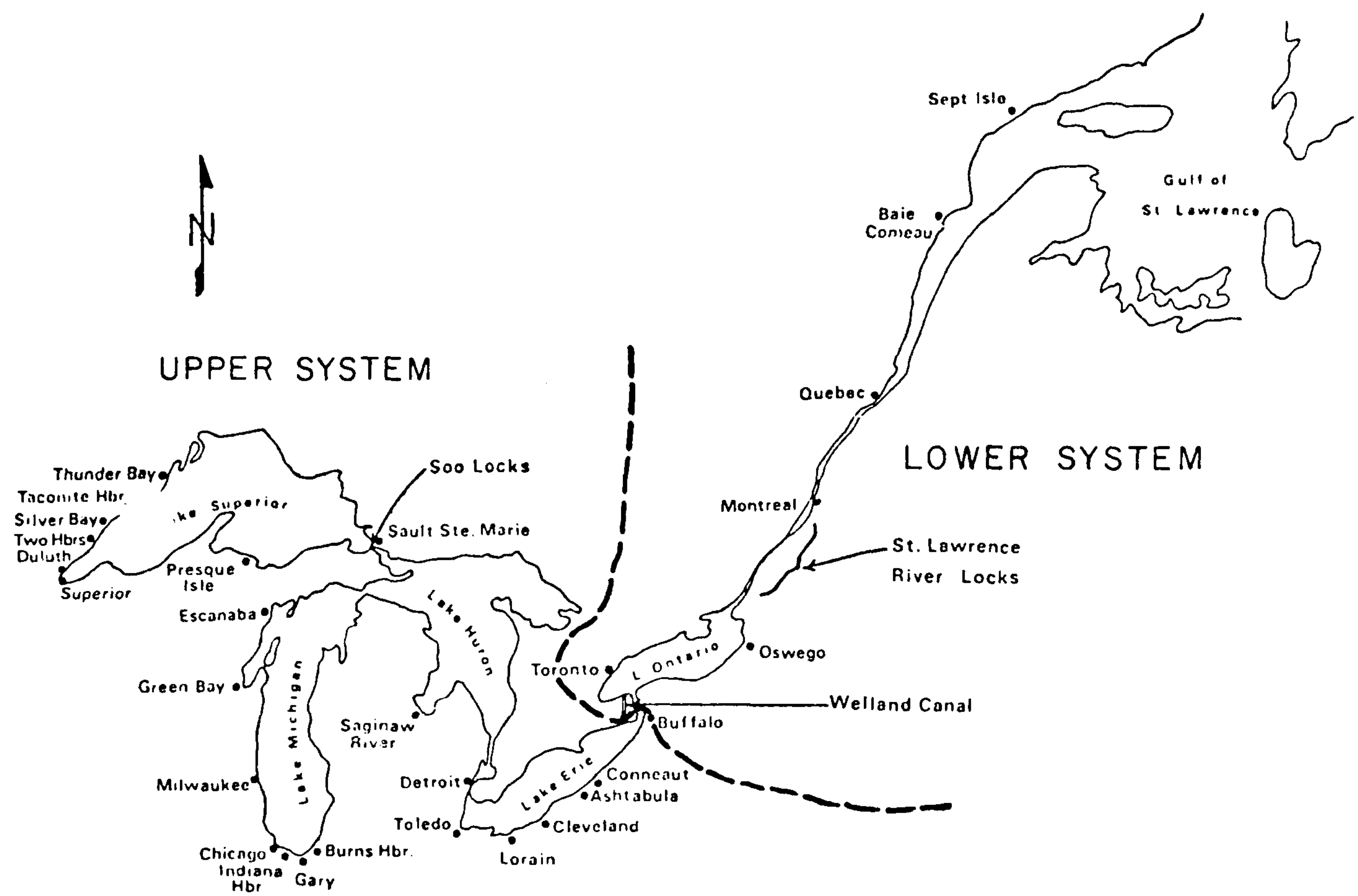



FIGURE 5. THE GREAT LAKES - ST. LAWRENCE SEAWAY SYSTEM

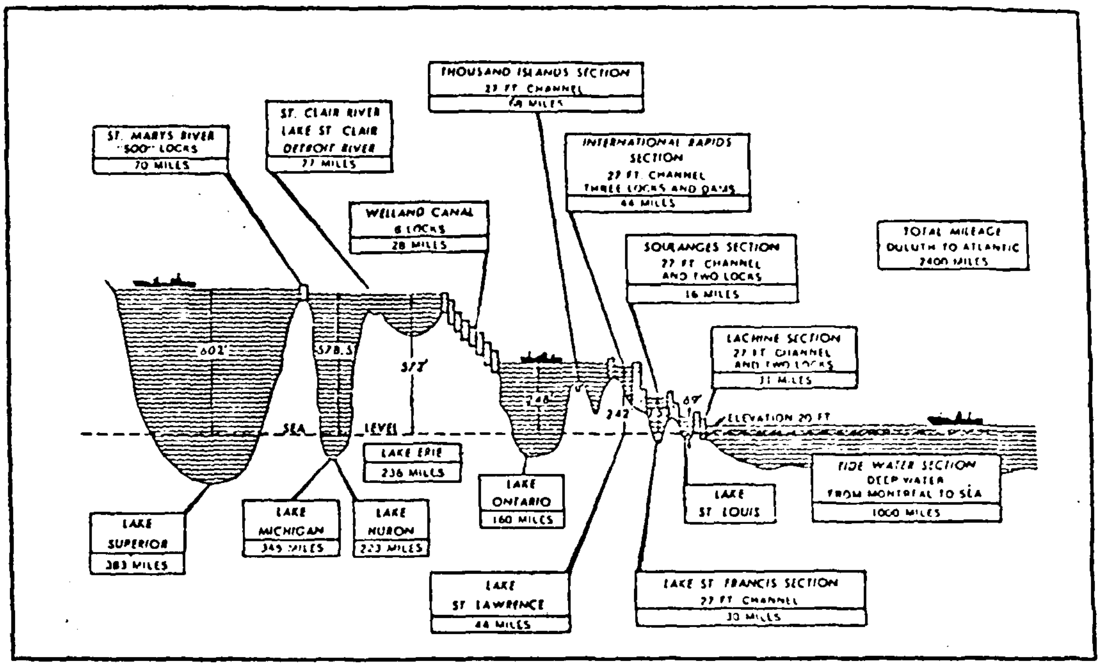



FIGURE 6 PROFILE OF GREAT LAKES-ST. LAWRENCE NAVIGATION SYSTEM

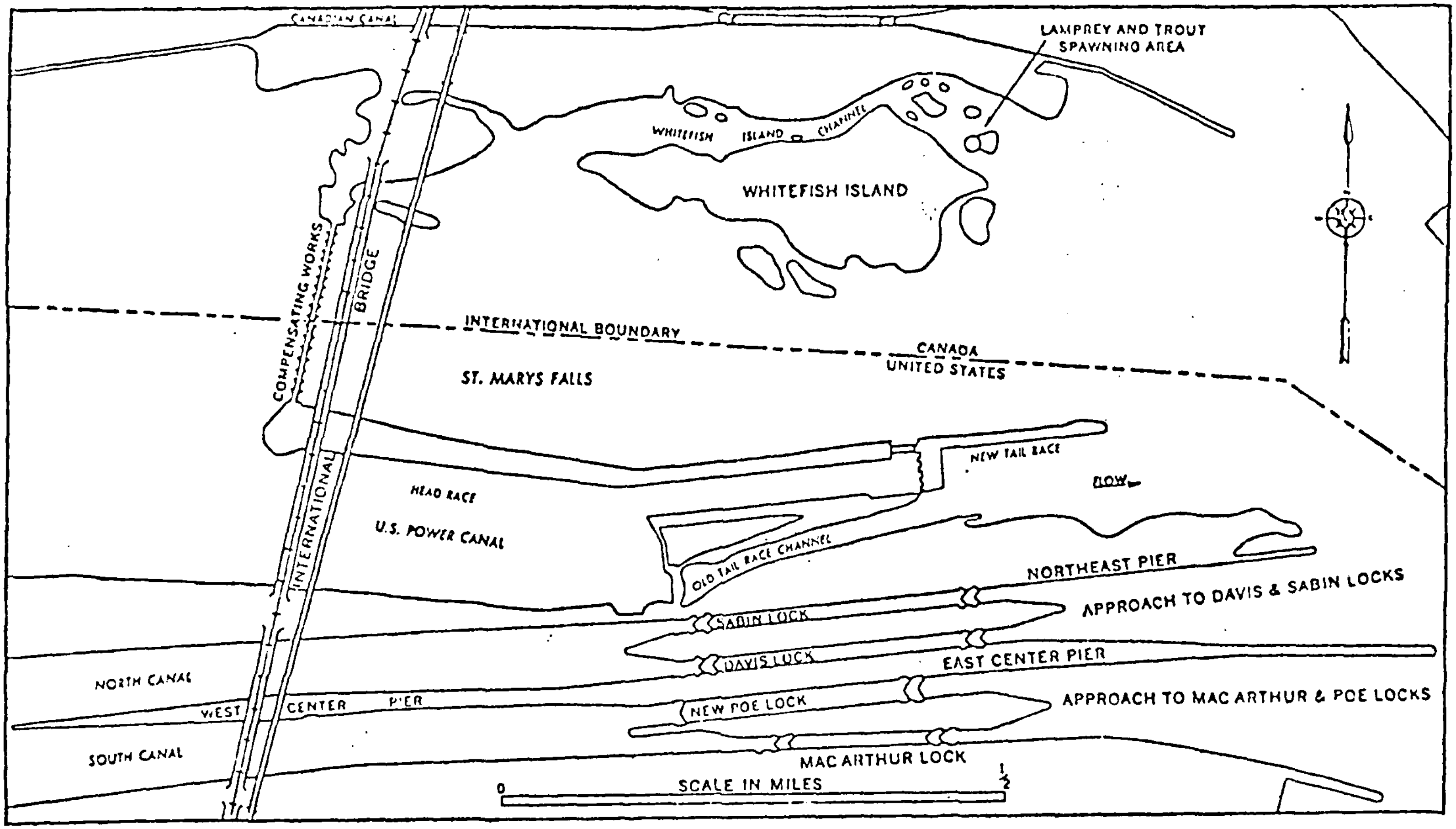



FIGURE 7 SOO LOCK SYSTEM

The existing length of the navigation season at the Soo Locks is 9-1/4 months $\pm$ 1 week, from about 1 April to 7 January. Figure 8 shows the past trend in length of season.

Table 1 - Soo Locks, Physical Characteristics

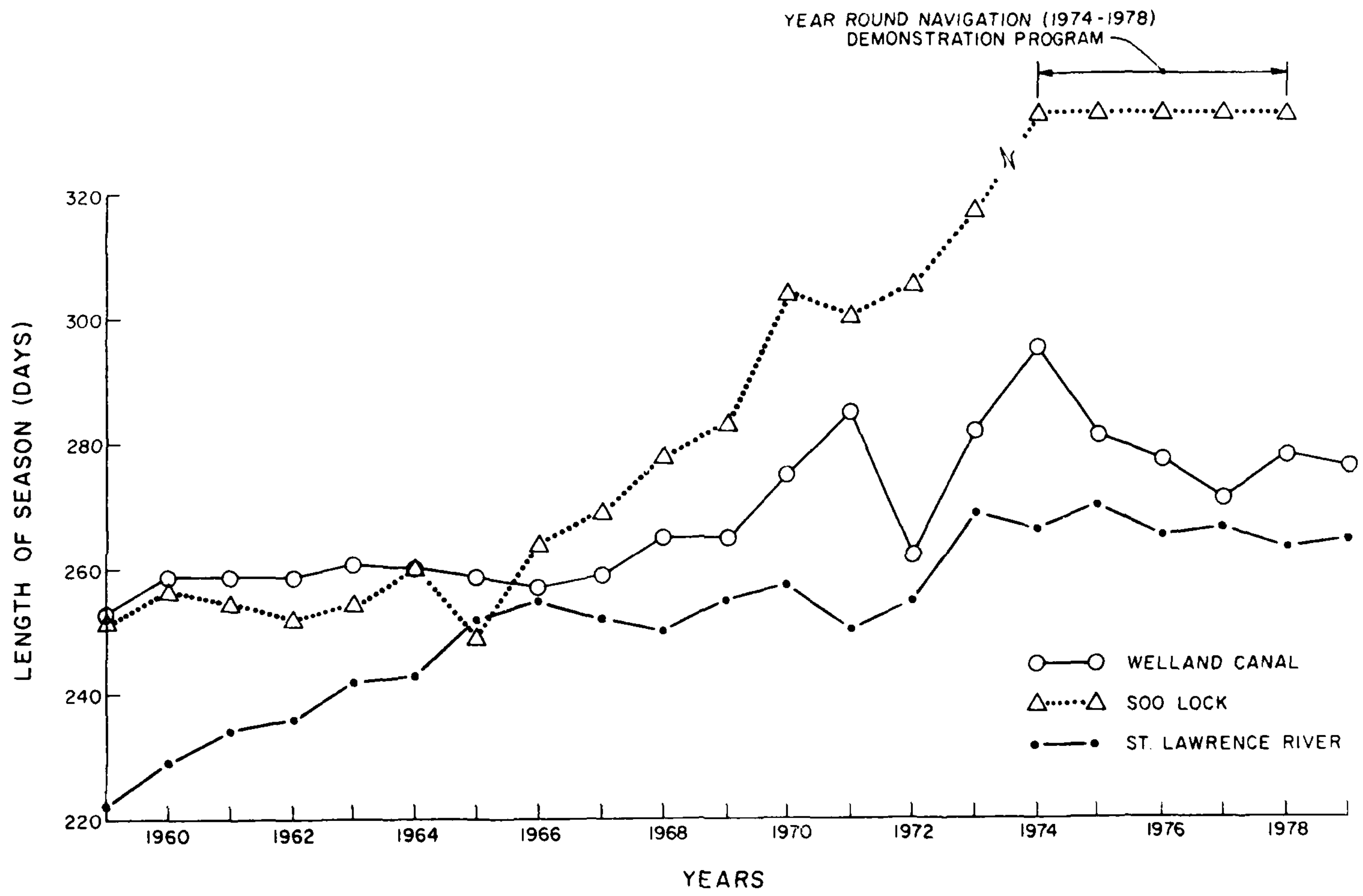
| Principal Features | MacArthur | Sabin | Davis | Poe | Canadian |
|---|---|---|---|---|---|
| Lock Width, Feet | 80 | 80 | 80 | 110 | 59 |
| Maximum Ship Beam, Feet | 75 | 75 | 75 | 105 | - |
| Length Between Mitre Sills, Feet | 800 | 1,350 | 1,350 | 1,200 | 900 |
| Maximum Ship Length, Feet | 730 (1) | 826 | 826 | 1,000 (2) | - |
| Depth on Upper Mitre Sill, Feet | 31 | 24.3 | 24.3 | 32 | 16.8 |
| Depth on Lower Mitre Sill, Feet | 31 | 23.1 | 23.1 | 32 | 16.8 |
| Lift, Feet | 22 | 22 | 22 | 22 | 22 |
| Year Built | 1943 | 1919 | 1914 | 1968 | - |

(1) 767-foot ships permitted with special handling.

(2) 1,100-foot ships permitted with special handling.

Welland Canal - The Welland Canal is located in Canada about 20 miles west of the Niagara River, and connects Lake Erie to Lake Ontario. It is 27 miles long and contains a series of eight locks. Figure 9 shows the layout of the canal and the locations of the locks. Table 2 shows the physical characteristics of each of the eight locks.

Of the eight locks, Locks 1 through 7 are lift locks, while Lock 8 is primarily a guard lock. Locks 1, 2, 3, and 8 are single locks that handle both upbound and downbound traffic. Locks 4, 5, and 6, called "flights" because they resemble stairs, lift ships a total of 135 feet over the Niagara Escarpment. These locks are twinned permitting parallel traffic, but each set of three locks is essentially a single lock system because once a ship enters, it must be locked all the way through before the next ship is serviced. Lock 7 is a lift lock and considered to be the most constraining lock in the system because of its longer locking time and because of its somewhat curving channel located only about 1,800 feet away from the flight locks. The existing length of the navigation season at the Welland Canal is 9 months, from about 1 April to 31 December (see Figure 8).




LENGTH OF NAVIGATION SEASON AT THE LOCK NODES
WITHIN THE GREAT LAKES/ST. LAWRENCE SEAWAY SYSTEM (1959-1979)

FIGURE 8

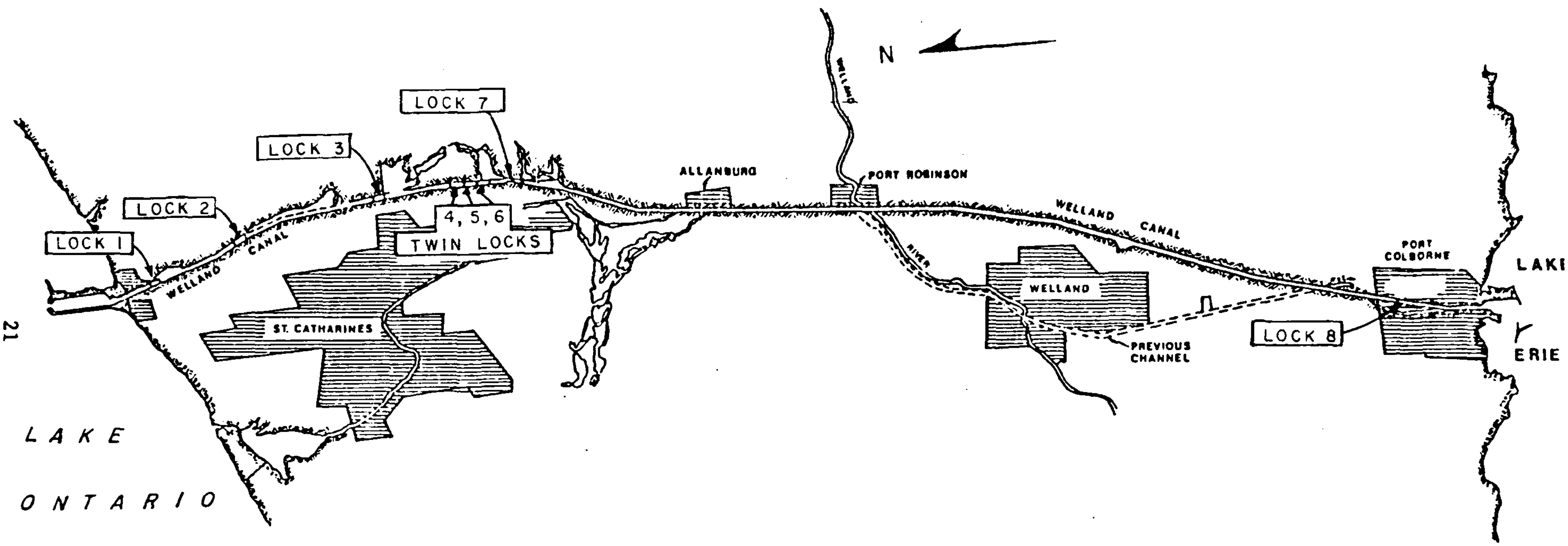



FIGURE 9 THE WELLAND CANAL AND LOCKS

St. Lawrence River Locks - There are seven locks in the portion of the St. Lawrence River between Lake Ontario and Montreal, Quebec. Figure 10 shows the location of the seven locks of which two are American, the Eisenhower and Snell locks, located near Massena, NY; and the remaining five are Canadian, the St. Lambert and Cote Ste. Catherine locks near Montreal, Quebec; the Upper and Lower Beauharnois locks in the Beauharnois Power Canal; and the Iroquois lock near Iroquois, Ontario. Table 3 lists the physical characteristics of each of the seven locks. The Eisenhower and Snell locks are shown in Figures 11 and 12, respectively.

Table 2 - Welland Canal Locks, Physical Characteristics

| Lock | Length (feet) | Width (feet) | Depth Over Sills (feet) | Lift (feet) | Year Built |
|---|---|---|---|---|---|
| All Locks | 766 (1) | 80 | 30 | 46.5 (3) | 1932 |
| Maximum Ship Size | 730 | 76 | 26 (draft) | | |
| Lock 1 | 865 (2) | | | | |
| Lock 2-7 | 859 (2) | | | | |
| Guard Lock 8 | 1,380 (2) | | | | |

(1) Breast wall to gate fender.

(2) Center to center of inner gate pintles.

(3) Lift for locks 1 to 7; variable lift for Lock 8, normally less than 3 feet.

The major constraint to traffic in the St. Lawrence River is generally considered to be the Beauharnois locks. These locks are relatively close together and provide no waiting area for vessels between the locks. In addition, during the peak summer months, the Beauharnois locks experience a strong seasonal demand for lockages by pleasure craft that are cruising in the vicinity of Montreal, Quebec. The existing length of navigation season at the St. Lawrence River is 8-1/2 months (with daylight-only operations for the first and last two weeks of the season), from about 1 April to 15 December (see Figure 8).

Locking Process - Locks were placed on the Great Lakes/St. Lawrence Seaway system to allow passage of vessels where the natural conditions of rapids and waterfalls made navigation impossible. The locks allow navigation through the waterways while maintaining relatively large differences in water level between the upstream and downstream sides of the lock. The locks also allow for the installation and operation of several hydroelectric power generating stations without preventing vessel use of the system.

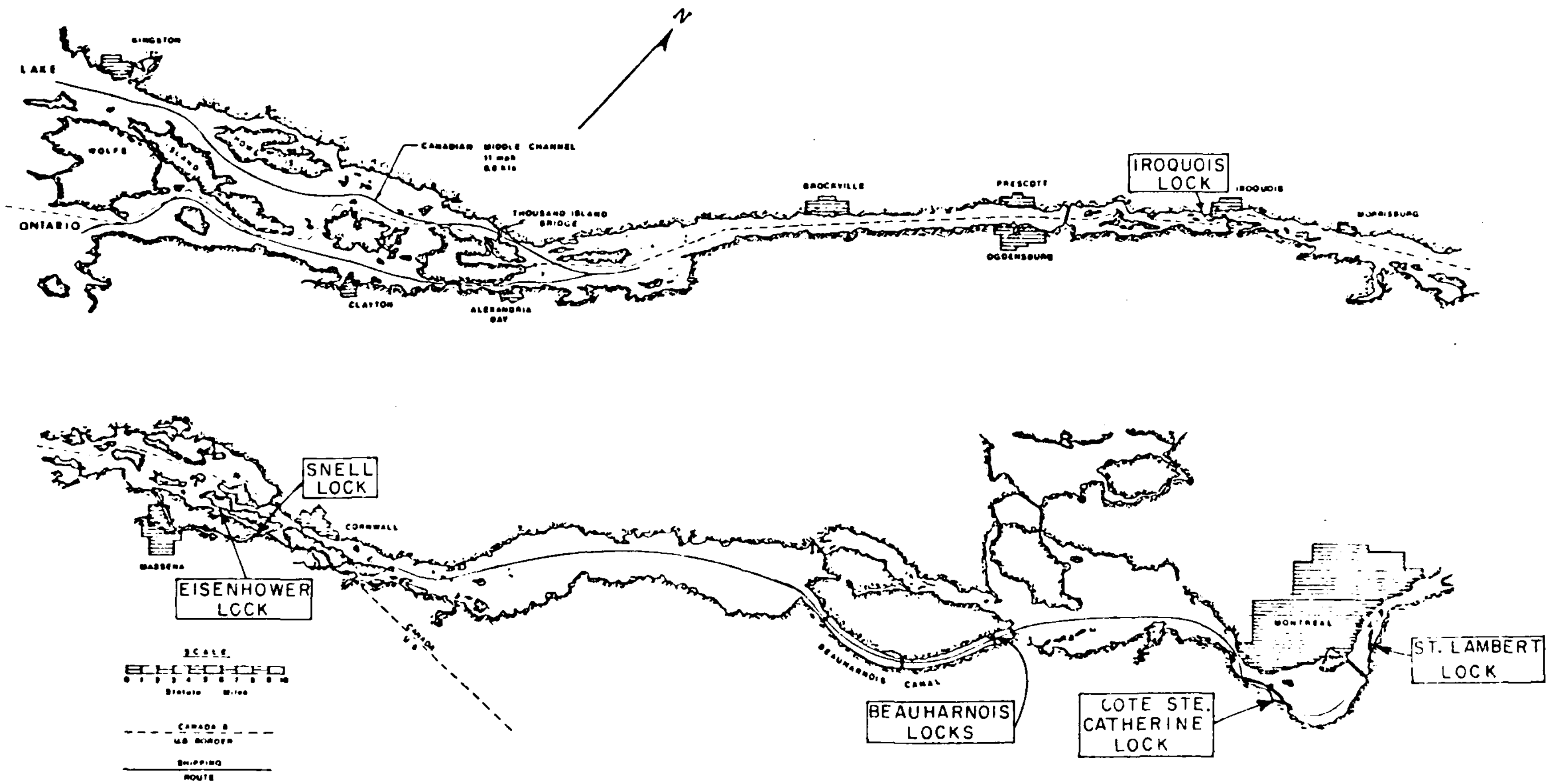
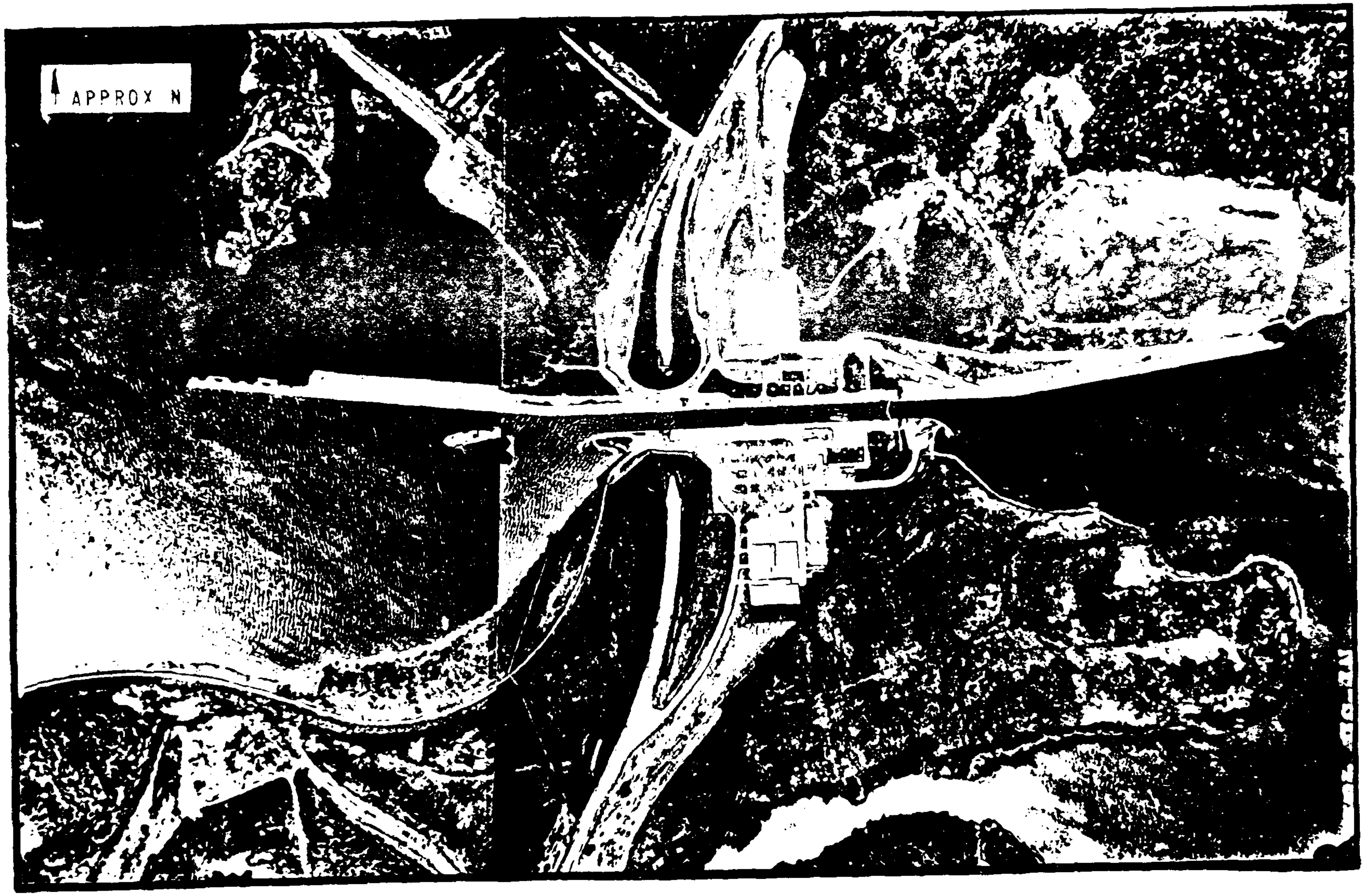
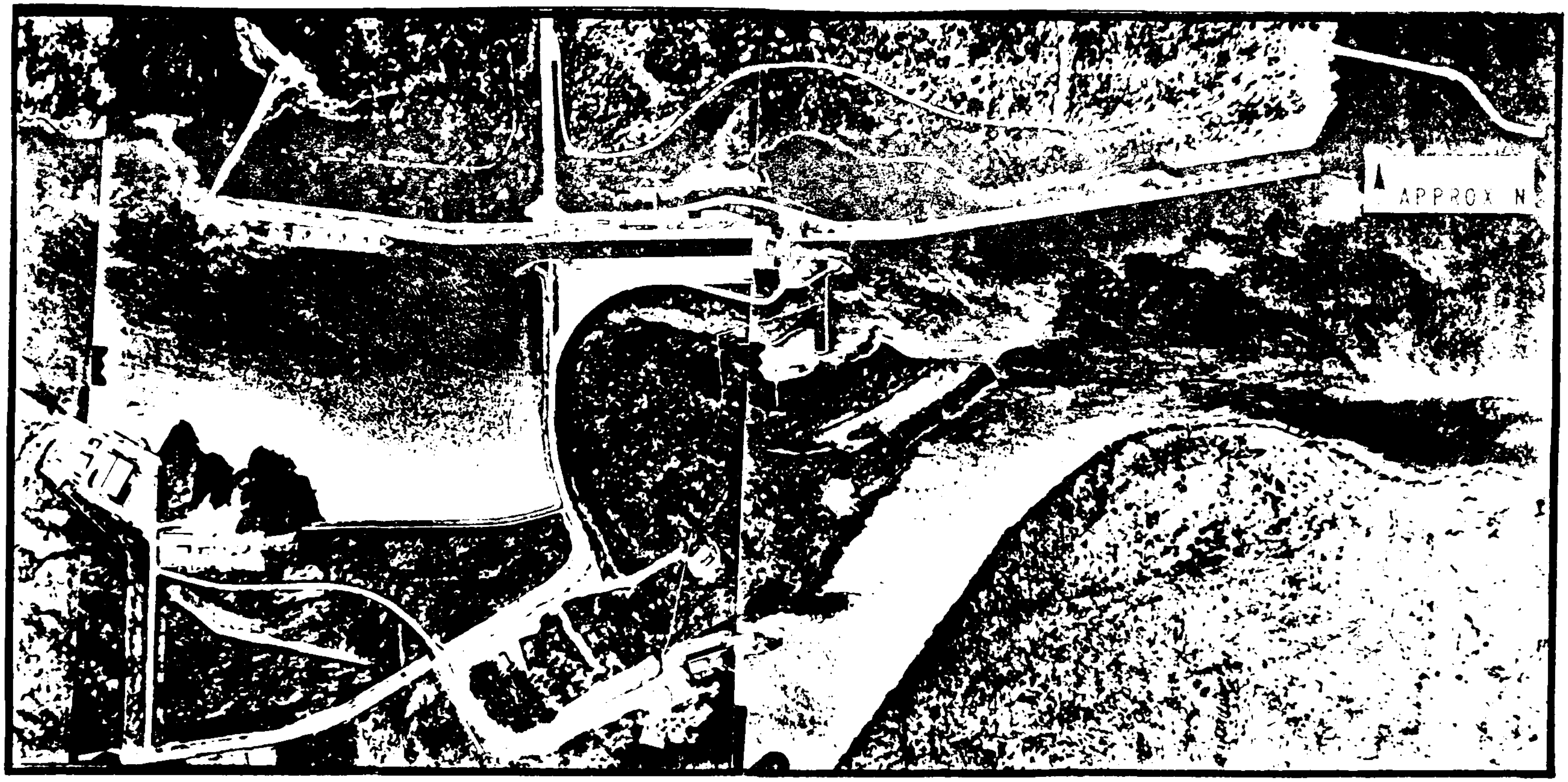



FIGURE 10. THE ST. LAWRENCE RIVER CHANNEL AND LOCKS




NOT TO SCALE

FIGURE II  EISENHOWER LOCK




NOT TO SCALE

FIGURE 12 SNELL LOCK

Table 3 - St. Lawrence River Locks, Physical Characteristics

| | |
|---|---|
| <u>All Locks</u>: | |
| Length, Breast Wall to Gate Fender | 766 Feet |
| Width | 80 Feet |
| Depth Over Sills | 30 Feet |
| Ships may not exceed 730 feet in overall length or 76 feet in maximum beam or 26 foot draft | |
| <u>Locks, Lift</u>: | |
| St. Lambert | 13 to 22 Feet |
| Cote Ste. Catherine | 28 to 37 Feet |
| Lower Beauharnois | 38 to 42 Feet |
| Upper Beauharnois | 36 to 40 Feet |
| Snell | 45 to 49 Feet |
| Eisenhower | 38 to 42 Feet |
| Iroquois | 0.5 to 6 Feet |
| All locks were operational in 1959. | |

Vessels using the locks on the GL/SLS system range in type and size from pleasure craft as small as 20 feet long to ocean and lake carriers 730 feet long and 76 feet wide in the St. Lawrence River and Welland Canal locks, up to lake carriers 1,000 feet long and 105 feet wide at the Soo locks.

Details of the locking process are presented here to further understanding of the system. A basic lock operating cycle is illustrated in Figure 13. The details of the locking process will vary depending on the type and size of the vessel, weather conditions, lockage demand, and on the individual lock characteristics. However, the general locking process is always the same. When a vessel reaches a lock approach, it will either be told by the lockmaster to proceed into the lock or it will moor alongside the approach wall until permission is received to enter the lock. The vessel must wait if the lock is occupied, if the lock is being recycled (turn back), or if there are other vessels waiting ahead of it.

After being given the go-ahead, the vessel will proceed into the lock at a very slow rate of speed as instructed by the lockmaster, and as dictated by the locking procedures for that particular lock. When the vessel has entered the lock, it will be moored. One or more vessels may be brought into the lock if the vessel sizes permit a tandem or multiple vessel lockage. Once the vessel(s) are in place, the rearward gates of the lock will be closed. Then, the required valves will be opened and the chamber will be emptied (dumped) or filled depending on whether the vessel(s) are transiting from higher to lower, or lower to higher water. This process is called chambering. When the new water level has been reached, the forward gates will be opened, the mooring lines will be cast off, and the vessel(s) will proceed out of the lock.

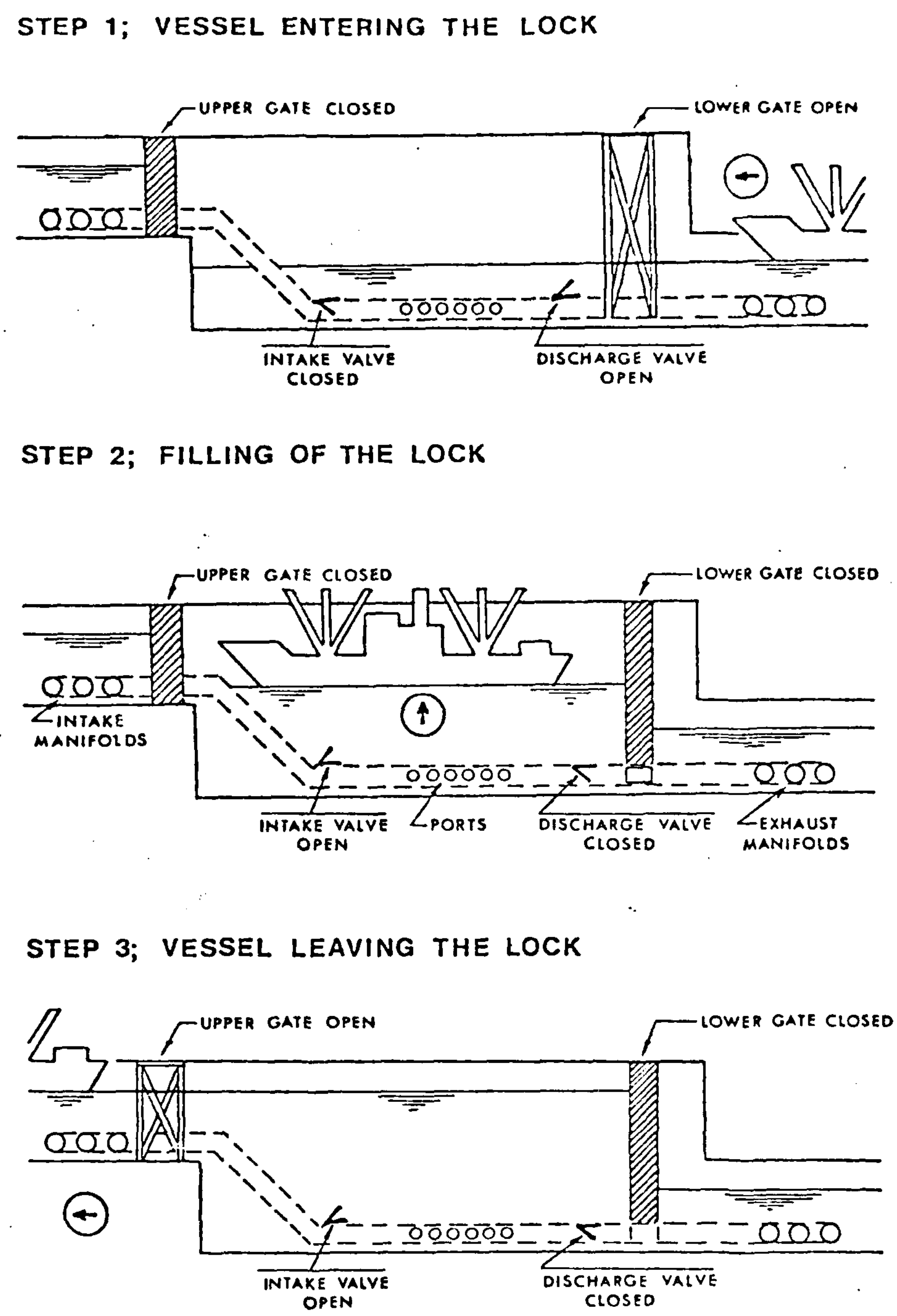



FIGURE 13 BASIC LOCKING PROCESS

The time required to process a vessel through a lock (locking time) can be broken down into a small or large number of components. One of the more elementary breakdowns consists of three components as follows:

- Entrance Time - Time from vessel arrival to vessel mooring inside the lock.
- Chambering Time - Time required to close the rearward gates, empty or fill the lock, and open the forward gates.
- Exit Time - Time from completion of chambering until the lock is ready to accept another vessel.

The length of the locking time is dependent upon individual lock characteristics, vessel characteristics, the preceding lock cycle, weather conditions, level of traffic, and equipment failures. Improper positioning of the vessel to be locked next would cause additional delays.

The lock characteristics mainly affect chambering time. Gate opening and closing times are basically functions of the operating machinery. Dump/fill times are functions of the size of the chamber and the lock culverts. In general, differences in chambering time because of differences between lock designs are negligible. However, during extended season operations, lock designs can affect lock chambering times.

Vessel characteristics do not affect dump/fill times because the amount of water which must be moved into or out of the lock is independent of vessel size. Large vessels, especially those approaching maximum vessel size for the lock, will increase entrance and exit times. The larger ships must move slower and will require extra maneuvering time in order to safely enter and exit the lock and clear other vessels. Specific vessel classes may require special handling procedures.

During periods of equal amounts of upbound and downbound traffic, vessels can be locked "on the fly." That is to say, vessels are locked in alternate upbound and downbound directions, eliminating the need for turnback lockages. When traffic is primarily in one direction, turn-back lockages are required. After a vessel is locked through, the gates must be turned back and the lock must be emptied or filled so that the next vessel may be taken from the same direction.

(2) Channels

The navigation channels which connect the GL/SLS are: the St. Marys River, Straights of Mackinac, St. Clair River, Lake St. Clair, and the Detroit River in the Upper portion of the system; and the Welland Canal and the St. Lawrence River on the Lower portion of the system (see Figure 5). The controlling depth in these channels is 27.0 feet below LWD. Widths and lengths vary. Table 4 summarizes the physical characteristics of these existing navigation channels.

Connecting channels are maintained at the depth authorized by law; however, the actual depth of water in the channel varies because of daily and seasonal weather conditions plus silting caused by channel flow. Seasonally, the depth of water in the channels is affected by the water level in the lakes. The average elevation of the lake surfaces varies from year to year and over longer periods of time, typically a decade or more. During any given year, the surface is typically lowest during the winter months and highest during the summer months. All water levels in this report are referenced to the low water datum (LWD) unless otherwise specified.

Table 4 - GL/SLS Connecting Channels, Physical Description

| Channel | Draft (Relative to LWD) (feet) | Length (miles) | General Channel Width (feet) | Fall (feet) | Restrictive Width (1) (feet) |
|---|---|---|---|---|---|
| St. Marys River | 27-30 | 63-75 | 300-1,500 | 22 | 75, 105 (2) |
| Straits of Mackinac | 30 | 0.8 | 1,250 | 0 | N/A |
| St. Clair River | 27-30 | 46 | 700-1,400 | - | 600 (3) |
| Lake St. Clair | 27.5 | 17 | 700-800 | 8 | N/A |
| Detroit River | 27.5-29.5 | 32 | 300-1,260 | - | 105 |
| Welland Canal | 26 | 27 | 192-350 | 326 | 76 (4) |
| St. Lawrence River | 26 | 189 | 225-600 | 226 | 76 (3)(4) |

(1) Lock widths show maximum ship size allowed.

(2) Parallel locks, not including Canadian Lock which is generally not used.

(3) Bridge restrictions.

(4) Lock restrictions.

Further descriptions of the connecting channels in the Upper portion of the GL/SLS are available in the report referenced in the introduction to this section. Additional description of the navigation channels in the Lower portion of the system follows.

Welland Canal - The navigation channels in the Welland Canal are somewhat restricted by structures, has some hazardous areas, but has no levels and flows problems because it can be totally controlled by locking operations. The structural restrictions and the hazardous areas are described in the following paragraphs.

The Welland Canal is crossed by 12 bridges, four railroad and eight highway. Two road tunnels cross under the canal, one at Thorold south of Lock 7 and one at the By-Pass Channel north of Mile 18. A road-rail tunnel also crosses under the By-Pass Channel south of Mile 20. The lift bridges and narrow channels are considered to be bottlenecks to vessel traffic.

All of the normal hazards to navigation occur in the canal; winds, restricted visibility, and navigation in restricted waters. Low visibility conditions are a particular hazard because of the danger of hitting a bascule bridge or a lift bridge. Collisions with bridges have occurred, and these accidents can cause the canal to be closed for a period of days. Navigation is also restricted in some areas because of one-way traffic. A 4.5 mile section of the reach between Locks 7 and 8 is restricted to one-way navigation. A phased widening program will reduce the length of the restricted channel to 3.0 miles for the 1982 season. The effect of the one-way restriction should be minimal after widening is completed. Hazards to navigation also occur because of ice. Ice presents problems in locking vessels - sometimes large floes of ice must be locked through separately, locking times are increased because of the ice that forms on the lock walls, and lock walls and gates must periodically be cleared of ice, which also delays the locking process. In the approaches to the canal, there is a ship traffic problem at Port Colborne caused by ships moving to and from fueling piers. At the other end of the canal, there is a problem of silting at the approach to the canal in Lake Erie.

St. Lawrence River - The navigation channels in the St. Lawrence River are somewhat restricted by structures, hazards to navigation, and seasonal water levels and flows problems. These restrictions are discussed in the paragraphs that follow.

There are 17 bridges across the St. Lawrence River. Minimum clearance height is 120 feet and minimum clearance width is 80 feet. Five of the bridges have the 80-foot clearance width while the rest have greater than 180-feet. Twelve aerial cables cross the river above St. Regis with clearance heights from 120 feet to 210 feet. Twenty-four submerged cables also cross the river.

Hazards to navigation such as cross currents, fog, and ice are discussed later in this section.

Lake Ontario has been regulated since 1958 by means of a control dam that spans the St. Lawrence River near Iroquois, Ontario, and by a powerhouse and dam at Barnhart Island, NY, near Corwall, Ontario. Control of Lake Ontario was authorized by the International Joint Commission as part of the St. Lawrence Seaway and Power Project to meet the criteria specified in the Orders of Approval of the International Joint Commission. Tidal variations from Quebec seaward are quite large, up to 8 feet; however, at Montreal and upstream the variation is only about 6 inches. Seasonal water levels and flows problems primarily occur along the International Section of the river. At the Upper Iroquois, seasonal water variations result in water levels of more than 3 feet above datum through the summer. Summer water levels are likely to be only 1 or 2 feet above datum at other locations.

(3) Harbors

There are 42 commercial harbors in the United States portion of the GL/SLS system, some of which are shown on Figure 5. Of these harbors, there are 22 harbors which are currently maintained at the system authorized depth of 27.0 feet below LWD. These 22 harbors are all located in the Upper portion of the system and are identified in Table 5.

Physical descriptions of each harbor are not included in this report. However, the ARCTEC, Inc., report, cited earlier in this section, does give a full description of each harbor including actual and authorized draft, vessel restrictions, harbor facilities, length of navigation season, authority of maintenance, and planned harbor improvements.

Table 5 - U. S. Harbors in the Great Lakes/St. Lawrence Seaway System Maintained at System Authorized Depth

| Lake Superior | Lake Huron |
|---|---|
| Two Harbors, MN | St. Clair River, MI, St. Clair |
| Duluth-Superior, MN-WI | Port of Detroit, MI |
| Presque Isle, MI | Detroit Harbor, Rouge River, |
| Taconite, MN | Ecorse, Wyandotte, Riverview |
| Silver Bay, MN | |
| **Lake Michigan** | **Lake Erie** |
| Milwaukee, WI | Toledo, OH |
| Calumet Harbor, IN-IL | Lorain, OH |
| Lake Calumet | Cleveland, OH |
| Indiana Harbor, IN | Ashtabula, OH |
| Burns Waterway, IN | Conneaut, OH |
| Muskegon, MI | Erie, PA |
| Gary, IN | Port of Buffalo, NY |
| Escanaba, MI | Niagara River, Buffalo River |
| | Monroe, MI |

(4) Fleet Mix

The fleet mix depends on the existing requirements for shipping commodities or the relatively near term demand for commodities. Many other events also affect fleet mix, but the most important considerations are economic. Fleet building and retirements will follow demand and the economic considerations of operating vessels. When ships are built, they are generally the largest ships that can effectively meet the demands of a particular trade situation. The largest possible ship is not always built because of port limitations.

The current U. S. fleet (see Figure 14) is primarily composed of Class V ships (length of 600 to 649 feet) with a carrying capacity of about 15,000 DWT. The U.S. fleet also has ten 1,000-footers plus 13 ships in the Class

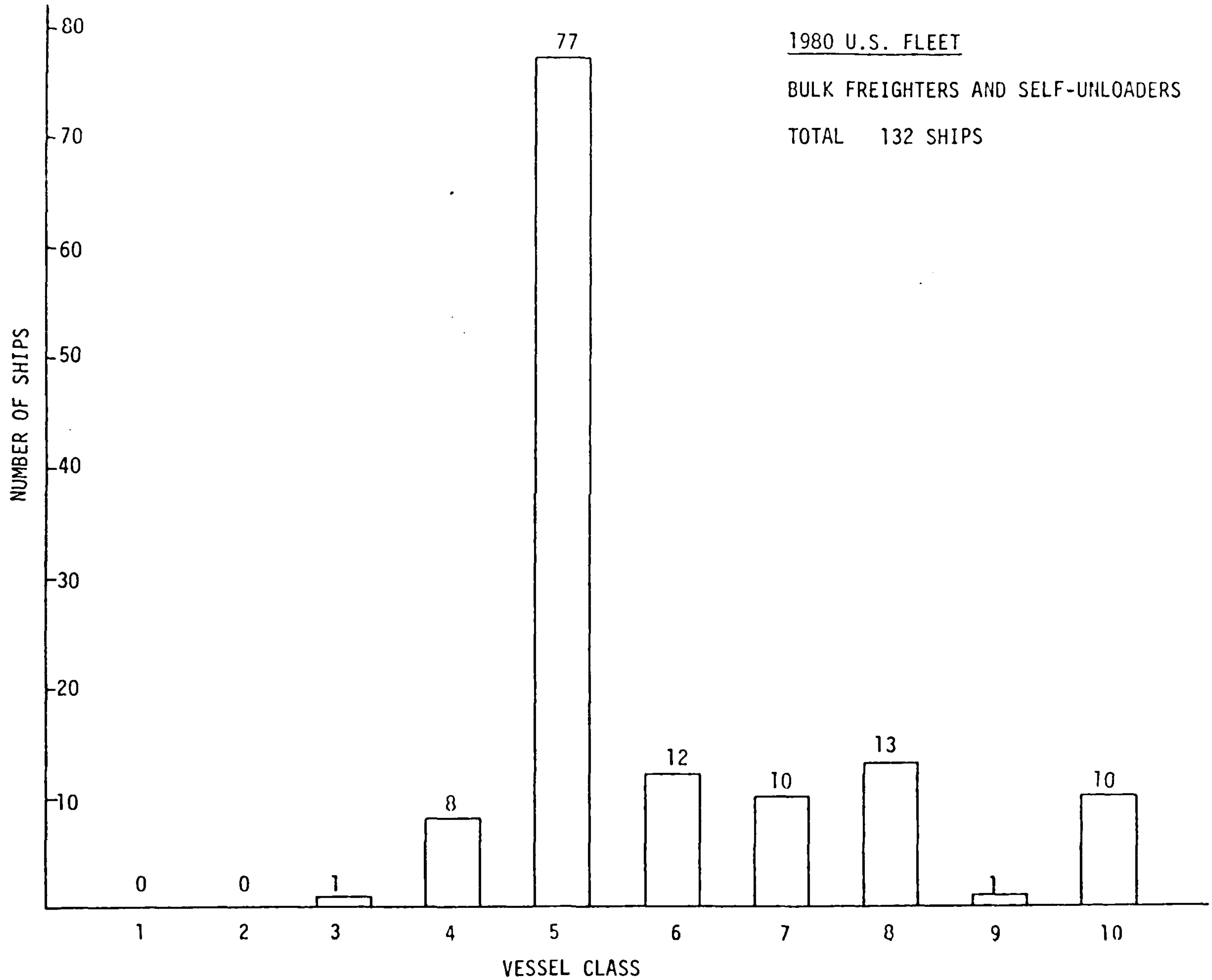



FIGURE 14 U.S. GREAT LAKES FLEET-BULK FREIGHTERS AND SELF-UNLOADERS

VIII category. The present Canadian fleet (see Figure 15) is predominantly Class VII vessels with a length of 700 to 730 feet and a carrying capacity of about 26,000 DWT. Figure 16 shows the combined U. S. and Canadian Great Lakes Fleet. Table 6 shows the ship classification system used in this study.

In the past 10 years, most U. S. shipbuilding has been in Class V vessels to serve customers in small ports, and in Class X vessels to increase the efficiency of operations to large ports. Canadian shipbuilding continues to concentrate on the Seaway Class VII vessels, with a lower level of construction in the smaller vessels of Class IV and below.

Table 6 - Ship Classification System

| Vessel Class | Vessel Length Range (Ft) Min | Max | Mean Vessel Speed (MPH) | Maximum Carrying Capacity (S. Tons) | Capacity Increase With Draft (St/In) |
|---|---|---|---|---|---|
| I | (Pleasure Craft, Noncommercial Vessels, and Ice Lockages) | | | | |
| IV | 0 | 599 | 13.8 | 9,500 | 0.0 (1) |
| V (2) | 600 | 699 | 13.9 | 21,000 | 91.8 |
| VI (3) | 400 | 699 | 14.7 | 15,000 | 61.8 |
| VII | 700 | 749 | 14.7 | 27,000 | 113.1 |
| VIII | 750 | 849 | 14.9 | 28,000 | 115.6 |
| IX | 850 | 989 | 14.9 | 45,000 | 167.1 |
| X | 990 | 1,099 | 14.9 | 60,000 | 207.1 |

(1) Class IV vessels cannot exceed design draft.

(2) Class V includes lake vessels of Classes V and VI.

(3) Class VI is for ocean vessels.

b. Natural Environment.

The parameters described in this section and in the section on socioeconomics are used to define existing conditions outside of those previously described in the navigation system section. The parameters used here will not always be bounded by the limits of the study area but will often cover a larger or smaller area and may be considered with geographical or political boundaries. Where data is nonexistent for the desired area, known data that does exist for a larger or smaller area is then presented so inferences can be made. The following paragraph outlines some of the divisions used to define parameter bounds.

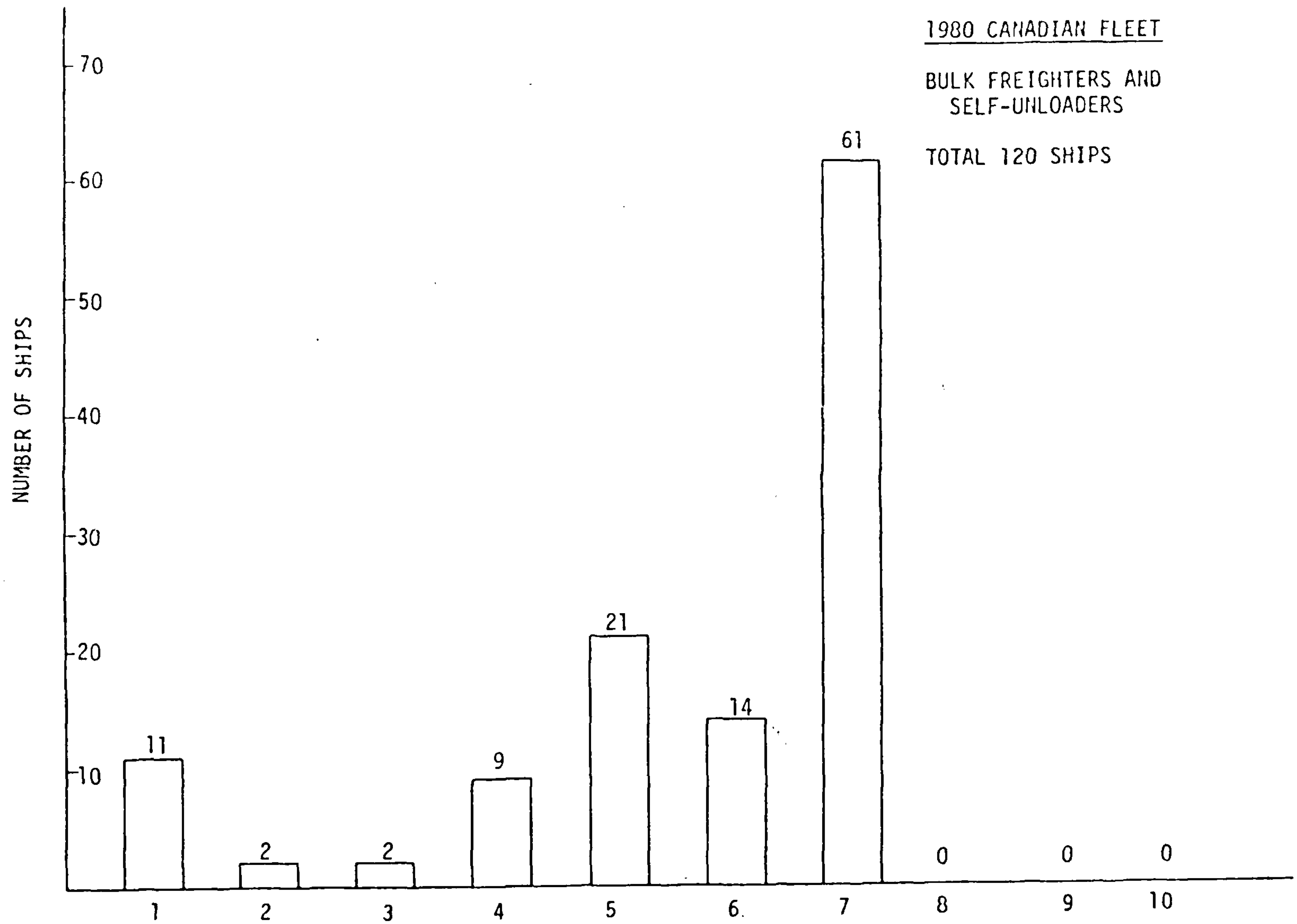



FIGURE 15 CANADIAN GREAT LAKES FLEET - BULK FREIGHTERS AND SELF-UNLOADERS

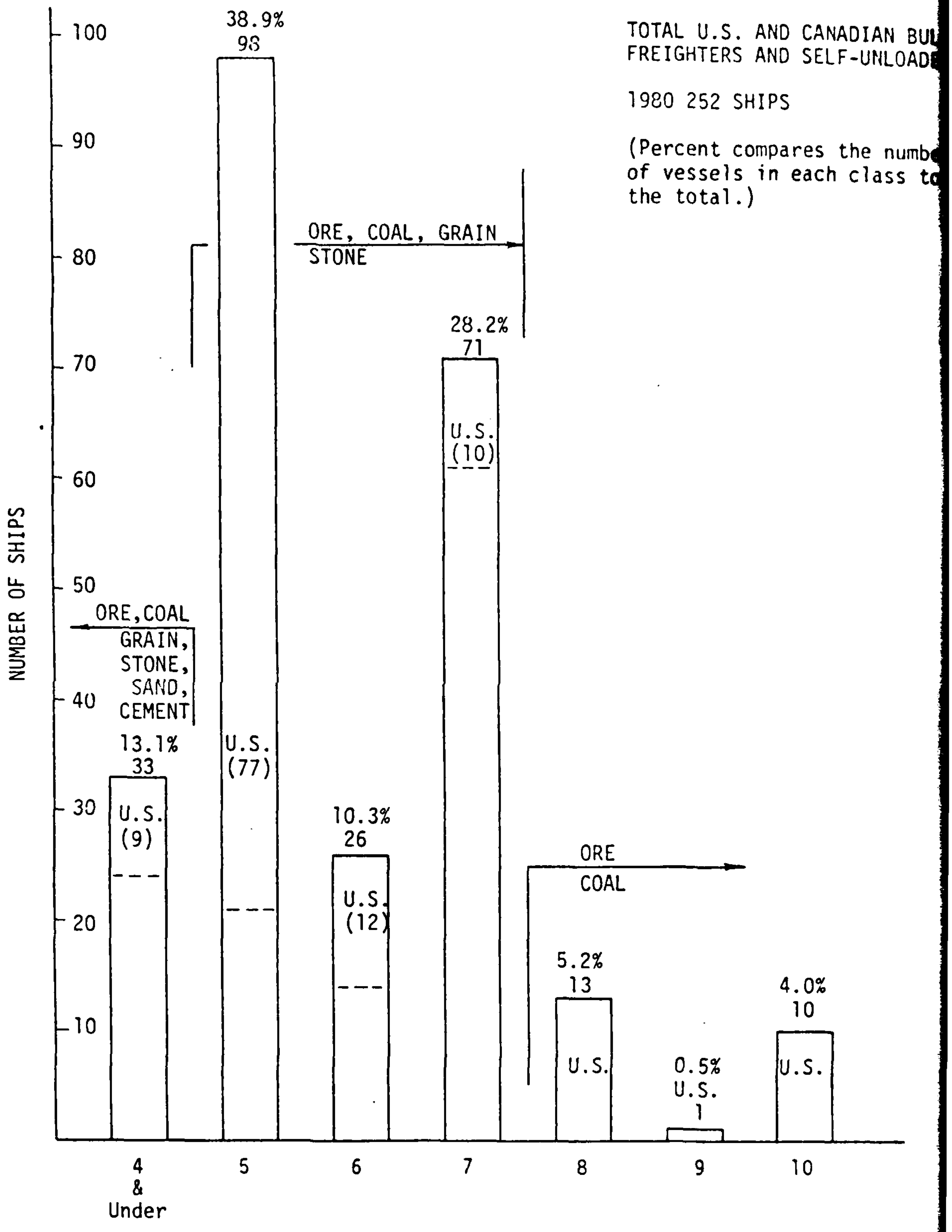



FIGURE 16 U.S. AND CANADIAN GREAT LAKES FLEET - BULK FREIGHTERS AND SELF-UNLOADERS

The largest area of significant importance in this study is the International area which borders the Great Lakes/St. Lawrence Seaway (GL/SLS) system along with adjacent economically affected areas. The U.S. portion of that area is the U.S. hinterland which was defined earlier under study limits as the eight states bordering the system and the eleven contiguous states. The Canadian portion of that area will only be loosely defined in the remainder of this report because the study authority does not allow for specific coverage in Canada. Further breakdowns may deal with only those states bordering the system called the Great Lakes States, but more significantly, the next largest breakdown will deal with New York State, the only state bordering on the Seaway portion of the GL/SLS system. Further breakdowns may be of geographical content covering the St. Lawrence River and its adjacent shoreline or of political content. The political areas including settlements and counties within New York State which border on the St. Lawrence River are: Cape Vincent, Clayton, and Alexandria Bay in Jefferson County and Morristown, Ogdensburg, Waddington, and Massena in St. Lawrence County. The smallest breakdown generally includes the area just northwest of Massena in St. Lawrence County, which is the area near to and including the Eisenhower and Snell Locks.

(1) Air

Air Quality - The St. Lawrence River area is generally classified as Level I, according to New York State's air quality classification system. Predominant use of Level I lands is for timber, agricultural crops, dairy farming, or recreation, and sparse industry. The area located within the corporate limits of Ogdensburg is classified as Level II and is predominately occupied by residences, small farms, and limited commercial services and industrial development. Another area located from the village of Massena eastward to the St. Lawrence-Franklin County line is classified as Level III. This classification is typified by dense populations, primarily commercial office buildings, department stores, and light industries in small and medium metropolitan complexes, or suburban areas of limited commercial and industrial development near large metropolitan complexes.

(2) Land

Geology - The St. Lawrence River is located in the St. Lawrence Lowland which forms the northern section of the St. Lawrence Valley Physiographic Province. The lowland is a broad area, less than 1,000 feet in altitude, bordered on the north by the Laurentian Plateau and on the south by the Uplands of the Adirondack Province. The present U. S. lock sites are located in the northeastern half of the St. Lawrence Lowland in the Oriented Till Ridges subsection. The subsection has widespread deposits of glacial till with only rare exposures of bedrock. Surface topography is controlled by glacial deposits rather than bedrock. The land in the near-regional vicinity of the locks is covered by a belt, about 18 miles wide, of low elongate ridges of till rising from clay and sand-filled intervening lowlands. The mounds of till trend in a northeast-southwest direction and are elongated parallel to the St. Lawrence River. These ridges have been worn down by waves and currents of the post-glacial Champlain Sea. The fine-grained

constituents of the till were winnowed out by wave action and washed into the lowlands. This left a coarse stony debris containing marine shells capping the crest of many of the hills. The blanket of glacial drift which overlies bedrock in this area varies in thickness up to 200 feet in places.

The lowland in the near-regional vicinity of the locks is underlain predominantly by flat-lying or gently dipping lower Paleozoic sedimentary rocks. These rocks, of chiefly Cambrian and Ordovician age, overlie a basement complex of Precambrian crystalline rocks. The strata dip gently northwestward in a homoclinal structure interrupted by tracts of flatlying or gently folded rocks. A major fault striking NW-SE is located on the Canadian side of the St. Lawrence River, northwest of Massena. If extended southeast it would enter New York about 3 miles southwest of the Massena Power Canal. Inclined to near vertical jointing is common in all of the consolidated rocks in this area. Isostatic rebound after the retreat of the Pleistocene glaciers was a major factor in producing the jointing. Horizontal or gently dipping fractures are also present.

The St. Lawrence Lowland is a region of relatively high seismic activity. On the Seismic Risk Map of the United States, the area has been given a Zone 3 classification. This means that major damage could occur due to seismic activity. The historical record of earthquake occurrences has been traced back to 1534. Several shocks with intensities as high as IX or X (on the Modified Mercalli Scale of 1931) have been recorded on the Canadian side of the lowland. In New York, intensities in the range of IV-V are more common, and shocks greater than VIII have not been observed.

The upper part of the bedrock forms a single, more or less, continuous aquifer which is confined (artesian) in most places. Fractures are the most important openings and waterways in the bedrock.

For a more detailed discussion of regional geotechnical information see Appendix C - Geotechnical.

The general site of the Snell Lock is located in a flat area underlain by marine clay. A typical cross-section through the general area would show, from top to bottom: backfill material, marine clay, glacial till, and dolomite bedrock. The marine clay is very soft, has a flocculent structure, and is extremely sensitive. The bedrock is dolomite for the most part but also contains shale and dolomitic shale layers. The movement of glacial ice across the bedrock surface caused fracturing or jointing in the rock and left striations on the rock surface. The bedrock is virtually unweathered except for the upper 10 feet of rock where some staining was observed along partings or bedding planes. There are zones of leached rock and small cavities or solution voids that are widely distributed in certain stratigraphic zones in the foundation rock of Snell Lock. A fault zone about 200 feet wide diagonally crosses the canal centerline upstream of Snell Lock. Rock units have been vertically displaced about 35 feet; the rock at and adjacent to the fault is badly brecciated and fractured.

The general site of the Eisenhower Lock is located on a major NE-SW trending till ridge. A general section of the area would show from top to bottom a

sequence of backfill, glacial till, and bedrock. The marine clay, common at the Snell site, is found overlying the fill only to the south and along the eastern slope of the hill. As at Snell Lock, the bedrock is predominantly dolomite with interbedded shale and dolomitic shale layers. Two gypsum beds are also present, and gypsum is irregularly distributed through some of the dolomite layers as thin seams along partings, as small stringers or veinlets, and as small irregularly-shaped replacement bodies. The bedrock topography is generally more gentle than at the Snell site. The rock strata are very nearly horizontal but have a slight general dip northwestward and contain small undulations. Three major joint sets occur at the site. The bedrock is virtually unweathered except for the upper 5 feet where some staining is present along partings. In the foundation rock of Eisenhower Lock thin zones of leached rock and small solution voids or cavities are widely distributed in certain stratigraphic zones. They are the result of leaching and solution by ground water.

Topography - In general, the topographic features within the Great Lakes/St. Lawrence Seaway System were created by the erosional and depositional processes of Pleistocene glaciation. The present topography consists of rolling hills and ridges, depressions with lakes and marshes, and both flat and sloping plains. Absent from the St. Lawrence River region are strong relief features. Relief reaches a maximum of less than 150 feet above area water level.

The St. Lawrence River follows a connecting chain of glacial depressions. The Great Lakes overflow simply spilled over from one depression to another, not always in a direct line and sometimes in violent rapids. In certain portions of its course, it occupies a broad valley-like depression where interior hilly areas have become islands within the river.

Prime and Unique Farmlands - No prime or unique farmland, as designated by the U.S. Soil Conservation Service, exists within the area of the existing locks.

Wetlands - Currently, all of the wetlands on the Great Lakes-St. Lawrence System have not been inventoried or uniformly classified. The U.S. portion of the St. Lawrence River contains approximately 7,000 acres of wetlands. However, in the Massena area, wetlands are few and small in size. Most of the wetlands are located in and along the river and consist mainly of emergent aquatic plants such as cattail.

(3) Biota

Vegetation - Conifers and deciduous forests, prairie grasslands, wetlands, bogs, and beach areas are interspersed throughout the Great Lakes/St. Lawrence River Basin, each with its own unique vegetation type. Shore zone areas contain rooted aquatics, with submergent macrophytes (plants large enough to be observed by the naked eye) becoming abundant in the shallower areas. Due to development, undisturbed forests are rare in the St. Lawrence River area. The Massena area (lock site) has basically five vegetative cover types: shrubland, deciduous forest, coniferous forest, open areas, and wetlands.

Benthos - Bottom composition is a significant determinant as to the type of benthic organisms present. Therefore, benthic populations are usually site-specific and vary within the study area. In the St. Lawrence River, fine particle feeding molluscs dominate the upriver areas (i.e., Cape Vincent), while in the downstream areas (existing lock areas) more coarse particle feeders predominate. Downriver biomass is dominated by chironomids, nematodes, and caddisfly larvae. In the Massena area; the abundance, biomass, and diversity of benthic organisms is considerably lower than in the rest of the river and species composition is relatively similar throughout the area.

Fish - More than 237 species and subspecies of fish occupy the Great Lakes/St. Lawrence River Basin. The commercial fishery is dominated by yellow perch, rainbow smelt, carp, catfish suckers, walleye, sheepshead, and whitefish. Most States within the basin have extensive stocking programs of both warm and cold water species which add significantly to sport fisheries.

The St. Lawrence River has an extensive fishery comprised of approximately 99 species, eleven of which are of significant recreational importance. The areas of the existing locks supports 35 species including numerous forage fish. These areas are important as spawning, nursery, and feeding areas.

Amphibians and Reptiles - The St. Lawrence River area supports 17 species of reptiles and 18 species of amphibians. These include various species of turtles, snakes, frogs, and toads. In the Massena area, most upland, wetland and pond habitats have some frogs and toads. The lock area, however, has no significant amphibian and reptile resources due to the rapidly rising and falling water level associated with lock operations.

Birds - Approximately 280 species of birds can be found within the basin. Within the Massena sector of the St. Lawrence River, there is a high proportion of shorebirds due to the presence of numerous shallow embayments and creek outlets. Common-term and Ring-billed gull colonies are also frequent here. The open-water areas are important staging areas for Canada geese and migratory ducks.

Mammals - The St. Lawrence River area supports a variety of species including rabbits, chipmunks, deer, and bear. The marshes of the river produce large numbers of furbearers including muskrat, beaver, mink, and raccoon. The muskrat is the most economically important of these species. The Massena area supports 18 species that are commonly found and 19 others that are either common to rare, rare, or seasonally found.

Threatened and Endangered Species - The Great Lakes/St. Lawrence River Basin is within the range of the following Federal Threatened or Endangered Species: Indiana Bat, Eastern Cougar, Gray Wolf, Bald Eagle, American Peregrine Falcon, Arctic Peregrine Falcon, Longjaw Cisco, Blue Pike, and one-plant species, Northern Wild Monkshood. Monkshood inhabits rich woodlands, shaded ravines and moist slope soils. Although the 20 May 1980 Federal Register of Endangered and Threatened Species indicates the plant is found in New York as part of its habitat, the Audubon Society Field Guide to North American Wildflowers (Niering and Olmstead 1979) lists this plant as occurring in the Catskill Mountain area of New York State.

The St. Lawrence River area is known to support three endangered species: Bald Eagle, American Peregrine Falcon, and Indiana Bat. In addition, Blandings Turtle-proposed for threatened status by New York State Department of Environmental Conservation - was seen in the existing lock area in 1978-1979. Once a final plan is selected, the exact project site would have to be surveyed to ensure protection of all protected plant and animal species.

(4) Water

Water Quality - Water quality within the U.S. portion of the St. Lawrence River is designated by the New York State Department of Environmental Conservation (NYSDEC) as Class "A". The "A" classification, one of the highest ratings given by NYSDEC, designates the water as suitable for drinking, culinary or food processing purposes, and any other uses. The high rating identifies St. Lawrence River water quality as a significant resource.

c. Socioeconomic Environment.

(1) Population

In 1970, more than 80 percent of the 20 million GL/SLR Basin residents lived in the major urban centers along the shores of Lake Michigan and Lake Erie. Population for the two counties which border the St. Lawrence River-St. Lawrence and Jefferson - totalled 111,000 and 89,000, respectively. Rural residents of Jefferson County constituted approximately 61 percent of the total population, while about 56 percent of St. Lawrence County's residents were classified as rural. The city of Ogdensburg, with a population of 15,000, the village of Massena, with a population of 14,000, both of which are located in St. Lawrence County, and the city of Watertown, located in Jefferson County and with a population of 31,000 comprise the major political subdivisions in the area.

Jefferson County showed a very modest growth trend through 1970, with a net increase of slightly less than 2,000 since 1950. St. Lawrence County experienced a considerably greater population increase from 1950 to 1960, at more than 12,000, but had only a modest net gain of about 1,000 from 1960 to 1970.

The St. Regis Akwasasne Indian Reserve is located on the St. Lawrence River, at the junction of the boundaries of the Provinces of Quebec and Ontario and the State of New York. The Reserve straddles the international boundary and includes within its area a number of islands, the largest of which is Cornwall Island. This area of New York State and Canada has been Mohawk hunting territory. The St. Lawrence County map indicates that this area was occupied intermittantly by tribes of the Iroquois and Huron Algonqu[illegible] from Canada, both using it for hunting and fishing grounds.

Estimates indicate that there are some 5,500 - 6,000 Mohawks living in Akwasasne. The population is constantly fluctuating for cultural and social reasons. People frequently travel between one Native area and another and may stay for long periods of time. People may leave to look for work in other parts of the State or Country and then return. (Lyons, 1981).

"Akwasasne Notes," a periodical published by the Mohawks at Akwasasne, estimates the residents on the American side of the Reservation to number 2,500 - 3,000 as of December 1972. Others note some 4,200 Indians on Cornwall Island, Canada (Macleans, 1980).

(2) Employment

Employment trends for the eight States bordering the Great Lakes have paralleled national employment shifts for most major employment sectors during the period 1940-1970. Declines in employment have been concentrated in the primary sector while strong gains in the secondary and tertiary sectors contributed to increases in total employment.

The combined number of employed persons in Jefferson and St. Lawrence Counties, as of 1970, was 68,000 out of a total labor force of approximately 72,000. Major occupation groups within the two counties include operatives, clerical workers, craftsmen and foremen, service workers, and professional and technical workers. The largest sources of employment for workers in Jefferson and St. Lawrence Counties are manufacturing and professional and related services, respectively.

(3) Income

Historically, total personal income and per capita income within the eight Great Lakes States has been associated with the heavy concentration of industrial activity. Basin personal income has averaged from 10 to 20 percent above the national average during the period 1950 to 1970.

As of 1969, median income for the 22,000 families in Jefferson County was $8,696, with the largest percentage falling within the $10,000 to $14,999 range. Median income for the 25,000 families in St. Lawrence County was $8,667, with 51.2 percent of these evenly divided between the $7,000 to $9,999 and the $10,000 to $14,999 income categories. Both counties lagged well behind New York State in both family and individual median income.

(4) Economic Development

The Great Lakes Basin is centrally located between the nation's important agricultural regions of the Midwest, the mineral resource regions of the northcentral States, and the heavily populated eastern markets. As a consequence of its physical location, the Basin has developed a major transportation network of national significance. In general, the region has all the attributes necessary for sustained long-term economic growth; fresh water supply, mineral resources, and waterways and connecting channels capable of the waterborne movement of bulk commodities at a low cost.

The St. Lawrence and Lake Ontario plain regions, a traditional center for agriculture, reflect the national trend of decreases in both total agricultural acreage and the number of farms. Outputs of this phenomenon are increases in average farm size and in levels of food production. In addition to agriculture, recreation and tourism are extremely important in the area adjacent to the U.S. portion of the St. Lawrence River.

(5) Land Use

The major land uses within the Great Lakes/St. Lawrence River Basin are forest lands (42.4 percent), agriculture (38.4 percent), and urban development (8.4 percent). Eighty percent of the land area is in private ownership. Extensive agricultural lands, existing in Ohio, Pennsylvania, New York, and southcentral Michigan, encompass 28.6 million acres of cropland and 3.5 million acres of pasture land. Potatoes, fruit crops, truck crops, and dairying dominate the agricultural scene. Representing only 8 percent of the total land use, projections indicate that urban development will increase in the Basin from 7.0 million acres to 12.1 million acres by the year 2020.

Within the St. Lawrence River and Eastern Lake Ontario region, rapid land use change is occurring as a response to highway construction, decreasing farm viability, and increasing demands for seasonal homes and recreational facilities.

(6) Recreation

The Great Lakes/St. Lawrence River Basin has 17.8 million acres of public recreation areas. The Basin contains a great diversity of outstanding natural features such as forests, meadows, marshes, shorelines, islands, streams, and lakes. Many of these areas have exceptional scenic, wilderness, and aesthetic qualities which make them nationally significant.

Currently, over 250 recreational facilities, mostly water-oriented are located within the project area. The majority of these have been developed since the opening of the Thousand Island Bridge in 1938. The water-oriented activities in these areas include swimming, boating, water skiing, fishing, and waterfowl hunting. The extensive water areas also provide an aesthetic backdrop for other activities including camping, sunbathing, picnicking, hiking, and golf.

(7) Transportation

Four commercial airports and seven general-purpose airstrips service the project area. Two limited-access highways - Interstate 81 and 87 provide north-south transportation in the area. East-west highway routes consist of local and county roads which are often not maintained during severe winter conditions. Rail service in the region is limited to freight handling. The GL/SLS navigation system, of primary importance, was covered previously.

(8) Power Resources

Of the 29,971 megawatts (mw) of power currently produced in New York State, 2,605 mw or 8.7 percent is produced along the eastern shoreline of Lake Ontario and the St. Lawrence River. In addition to major facilities along the shoreline, many small hydroelectric plants are located along the rivers which enter the area from adjoining upland areas.

The Power Authority of New York State operates the James A. Fitzpatrick nuclear plant at Ninemile Point in Oswego County and the Moses-Saunders Power

Dam at Massena in St. Lawrence County. Six privately-owned power units are located on the southeastern edge of Lake Ontario and additonal power stations are planned.

## FUTURE CONDITIONS

### a. Navigation System.

The possible futures presented in this section were developed considering a hierarchy of traffic forecasts. The two traffic forecasts considered were used to define a range of possible future commodity movement demands for the Great Lakes St. Lawrence Seaway system. Their detailed development is contained in Appendix B - Economics. The low forecast was developed specifically for this study, while the high forecast was selected from another recent source of forecast data to allow for an alternate forecast level test.

Figure 17 illustrates the low and high forecasts for both the Welland Canal and St. Lawrence River Locks. The figure shows the relative difference between forecasts up to the year 2050, and further shows the relationship between Seaway movements at the Welland Canal and the St. Lawrence River locks. The interdependency of these two subsystems is shown in this figure by the similar trend in tonnage. A more in-depth analysis of commodity movements also shows that relationship. This interrelationship of lock systems must be understood and accepted in order to see the derivation of the most probable future and other futures presented on the following pages. Also, the St. Lawrence Seaway is dependent on the Soo locks for all traffic movements which utilize all three of the lock nodes (i.e., Soo Locks, Welland Canal, and St. Lawrence River locks). This dependency, however, is less critical than the one between the Welland Canal and the St. Lawrence River locks. Figure 17a schematically illustrates the interdependency of commodity flows through the lower portion of the system. Systemwide traffic forecasts in the economic evaluation found in Appendix B illustrate this fact.

Once the traffic forecasts were developed and the interrelationship between the Welland Canal and the St. Lawrence River locks was established, a determination was made as to when the Seaway system would reach capacity. The analysis found the Welland Canal to be the constraint on capacity which was defined as either 80 or 90 percent lock utilization.
Once the capacity of the system was established, a determination was made of what changes, if any, could be made to the existing navigation system to accommodate the traffic forecasts. These changes to the existing navigation system were considered in a number of possible futures.

#### (1) Most Probable Future

The most probable future for the St. Lawrence Seaway, considering the traffic forecasts used in this study, is outlined in this section. To address the United States portion of the Seaway alone when developing the most probable future would be remiss because of the interrelationship of subsystems addressed earlier and because of the Canadian locks located both upstream and downstream. Therefore, the remainder of the Seaway, which is in Canada, is considered in the analyses. The Canadian part is the Welland

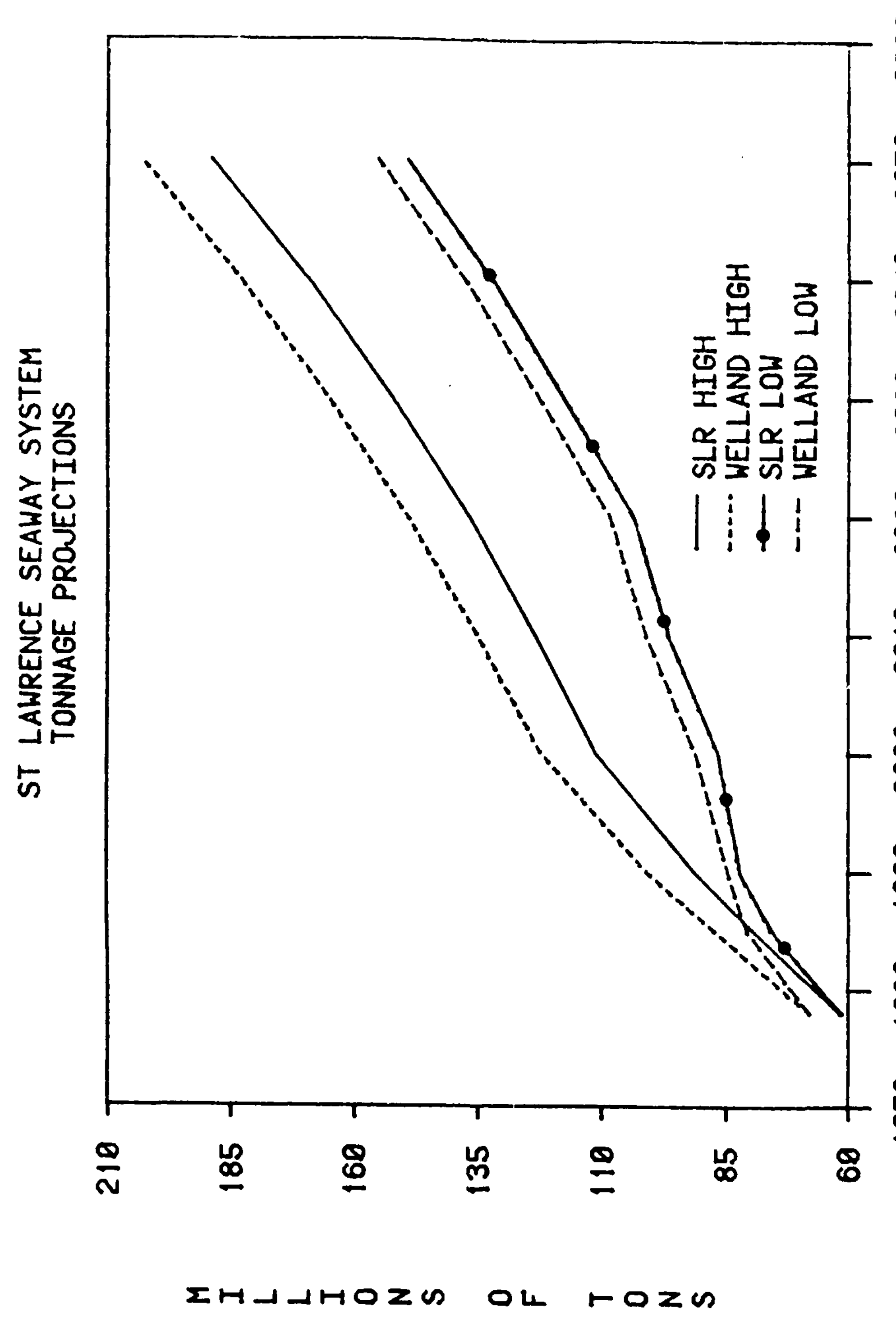

ST LAWRENCE SEAWAY SYSTEM
TONNAGE PROJECTIONS
SLR HIGH
WELLAND HIGH
SLR LOW
WELLAND LOW
210
185
160
135
110
85
60
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
MILLIONS OF TONS

FIGURE 17

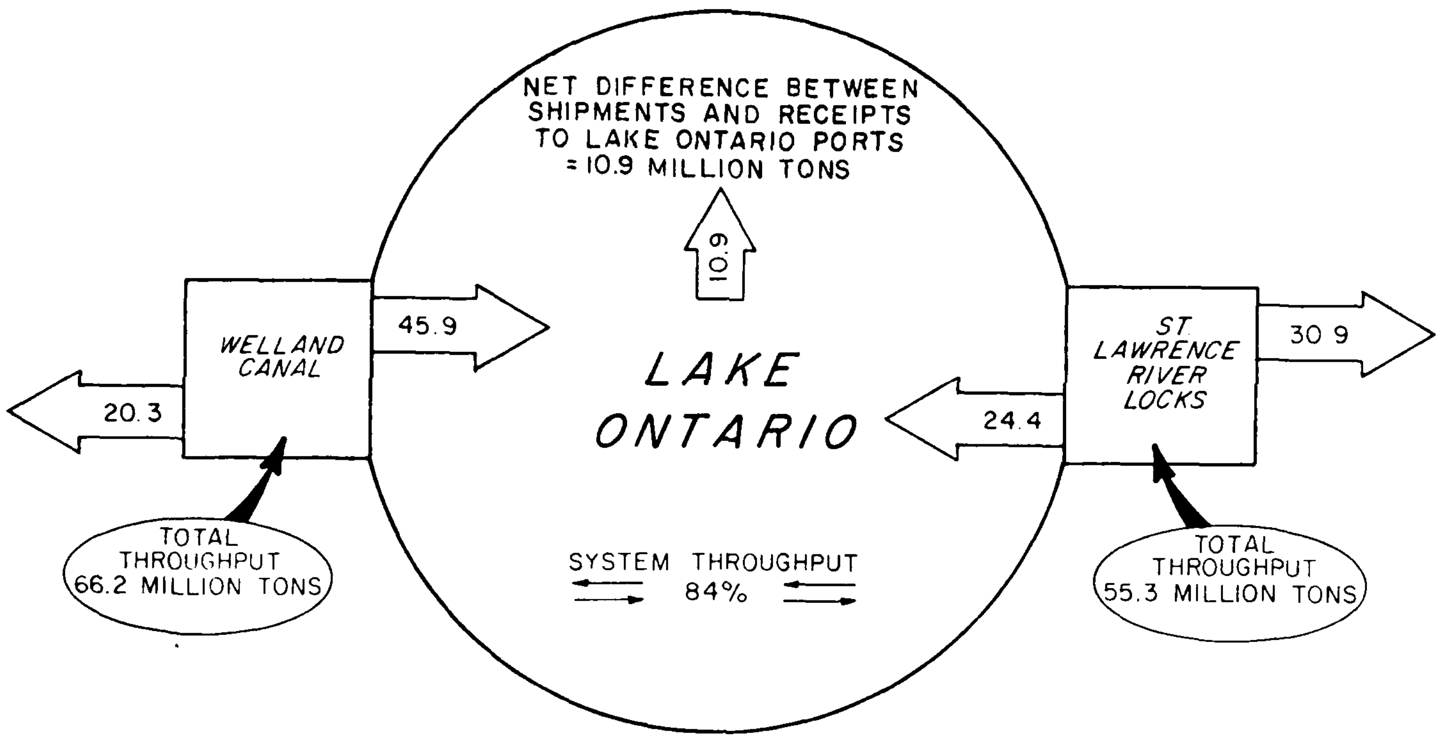



FIGURE 17A. INTER-RELATIONSHIP OF LOWER SYSTEM COMMODITY MOVEMENTS (1979)

(ALL NUMBERS IN MILLIONS OF TONS)

Canal from Lake Erie to Lake Ontario and the remaining five locks and channels in the St. Lawrence River. The development of the "most probable future" indicates both the projected future of this transportation system, and the informal plans of Canadian interests. This approach is taken to most accurately define the future, utilizing the best information available.

Primary in the development of the most probable future is consideration of the Welland Canal as the present limiting factor in the Seaway. The Welland Canal portion of the Seaway is approaching its capacity based on traffic forecasts shown earlier and capacity projections made by the operating agencies. The Canadians have made several nonstructural improvements since 1967 which have extended its expected capacity date. With the addition of further planned improvements, it is now expected to reach capacity in about 1995. If nothing is done to remove this constraint, it will force all additional forecasted tonnage to move via another more expensive, less energy efficient mode of transportation. This would in turn, result in higher total transportation costs, and hence higher costs for finished products. The effect would occur both in the United States and Canada.

All indications are that the Canadians plan to expand the capacity of the Welland Canal when it reaches capacity in its present configuration. They conducted a feasibility study in 1967 which recommended construction of a new series of larger locks and the necessary channel work to replace the current Welland Canal via a new route. The Canadian Government purchased the lands necessary for the replacement canal, but the combination of the recent economic recession and implementation of nonstructural improvements at the Welland Canal have delayed the need for the replacement canal. However, informal coordination with the St. Lawrence Seaway Authority indicates that nonstructural improvements will be used to the extent feasible and then a replacement for the Welland Canal will be built when the lock system finally does reach capacity.

When a series of Poe-sized locks (i.e., 1,200 feet long by 115 feet wide, or a series of any lock size larger than the existing locks) is available at the Welland Canal, the constraint in the St. Lawrence Seaway becomes the St. Lawrence River locks. Those locks must then be replaced by larger locks which are compatible with the Welland Canal improvement. It is assumed that the "new" Welland Canal will be planned considering criteria similar to those outlined in later sections of this report (for example: the economic life of the new system should approach 50 years).

Summarizing, the most probable future of the United States portion of the Seaway is linked to any improvement made at the Welland Canal by the Canadians. All evidence indicates a Welland Canal improvement will be made utilizing a larger size lock than currently exists in the Seaway, and that the St. Lawrence River locks will then become a capacity constraint. As defined, this most probable future is well suited to both the low and high traffic forecast scenario - although the specific lock size and channel depth combination may be different because of the relatively large difference between the two forecasts.

Figure 18 presents a time line showing the sequence of improvements for the Most Probable Future.

(2) Other Possible Futures

In addition to the "most probable future," there are "other possible futures" which are considered in the planning process. These futures are compared against the "most probable" to indicate the confidence limits of that particular selection. This section will outline three other possible futures in relative order of their potential feasibility. These other possible futures are also referred to as alternate futures 1 through 3.

The first possibility, alternate 1, differs from all other futures in that it assumes the new structural component at the Welland Canal will be Seaway-sized locks (same size as the existing locks). This is the only case where the St. Lawrence River locks will not reach their capacity until sometime after both nonstructural improvement and structural (locks) improvements are implemented. This future assumes that the improved Welland Canal will be operated as two parallel and independent systems of comparable size locks. This would assumably double the capacity at the Welland Canal and then the St. Lawrence River locks would become the constraint in the Seaway. Figure 18 illustrates the anticipated sequence of events for this future. This possible future will pass the forecasted tonnage for the high and low forecast.

The second possibility, alternate future 2, adds the measure of navigation season extension to the sequence of capacity expansion measures shown in the "most probable future" (see Figure 18). Season extension was not included in the "most probable future" of the Seaway system because:

(a) Its full-scale effectiveness has not been tested in the St. Lawrence River.

(b) The Canadians have prepared several reports on navigation season extension which conclude that it has marginal feasibility in extending capacity based on their point of view; and

(c) The position of New York State and other bordering States calls for no extension of the season until additional environmental studies are accomplished to quantify the possible impacts.

Despite these factors, there could be some level of limited season extension implemented by the time structural measures are required to expand capacity at the Welland Canal (i.e., 1995); however, it is not the most probable outcome. Season extension is included in the analysis of this report because it could postpone the date of investment for major structural improvements (i.e., larger locks and/or deeper channels). The approximate timing and sequence of events is shown on Figure 18. Note that the season extension measure could be added to the analysis at any point prior to a major structural improvement. The added increment could be a 2 to 6 week extension.

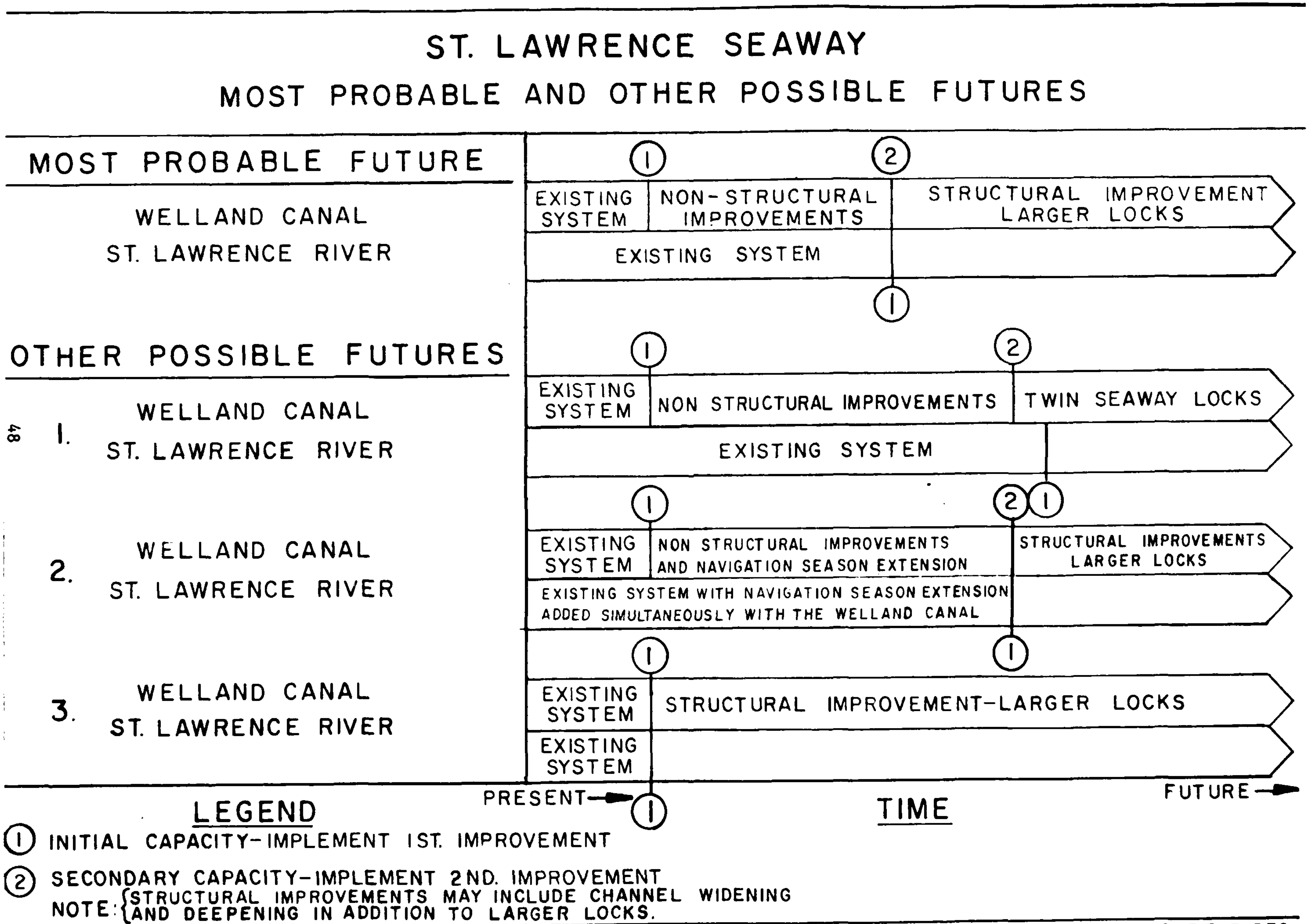



FIGURE 18 MOST PROBABLE AND OTHER POSSIBLE FUTURES

This would extend the base 8-1/2-month season to either 9 or 10 full months. This possible future is responsive to both the low and high traffic forecast scenarios.

The last considered possible future, alternate future 3, is similar to the "most possible future" in that the length of season remains constant (base condition) and larger locks (and deeper channels) are assumed to be the structural improvement at the Welland Canal. It differs from the "most possible future" in that it assumes there are no implementable nonstructural improvements, or that they are relatively unproductive (i.e., they are not engineeringly or economically feasible). In that event, the existing system would require improvement with larger locks much sooner than the case where nonstructural improvements significantly delay the capacity constraint at the existing Welland Locks. The pictorial sequence of this possible future is shown on Figure 18. The derivation of this possible future is most closely linked to a high traffic forecast scenario where traffic increases rapidly giving a short period of effectiveness for nonstructural improvements.

Summarizing, the three other possible futures presented here were developed to show what might occur if there were deviations from the considered most probable future. Consideration must be given to the fact that the most probable future selected is based on perceptions and forecasts which can change over time, especially given the human element. The other possible futures, were also developed for use as a measure of the stability of an alternative. The stability of an alternative being determined by analyzing the range of alternate futures that can be meaningfully addressed by an alternative. A plan highly suitable under all possible futures is most likely to be a stable plan.

b. Natural Environment.

Future conditions predict increases in annual tonnage being moved through the Great Lakes/St. Lawrence System. Although current legislation has as its goal the protection and improvement of air and water quality, these increases in Great Lakes traffic may result in a slight degradation of both, particularly in those areas where large numbers of ships congregate (e.g., harbors). Current improvement trends in water quality are expected to benefit fish and benthos populations. State fish stocking programs should continue to enhance the Great Lakes sport fishery.

The increased number of vessels could be a disruptive factor to local wildlife, particularly in constricted areas containing shoreline wetlands or in open-water areas utilized by waterfowl. The future protection of threatened and endangered species will depend upon the continuation of current protection status and the preservation of State and Federally identified critical habitat. Although environmental laws have been passed for the protection of wetlands, this aquatic resource is still declining nationally. Future conditions will depend on the enforcement of these laws and passage of additional legislation to further protect wetlands. Vegetational changes as well can be expected to accompany more intensive development and land use in the Great Lakes Basin.

c. Socioeconomic Environment.

The Great Lakes Basin share of the total U.S. population is anticipated to decrease slightly from 14.1 percent in 1980 to 13.5 percent in 2020. Nearly 23.5 million of the Basin's total population of 29.3 million resided in urban centers in 1970. This proportion is projected to remain stable during the 1980-2020 period. The Basin's share of national employment will fall slightly over the project planning period from about 15 percent to a low of 13.8 percent in 2020. Total personal income and per capita income will follow the same trends as population and employment during the 1980-2020 period. The Basin's share of national personal income is anticipated to drop from 15.4 percent (1980) to 14.5 percent (2020). Land use projections indicate that urban areas will increase from the present 7.0 million acres to 12.1 million acres by the year 2020.

In the eastern Lake Ontario region, which includes Jefferson and St. Lawrence Counties, the low population growth rate in the 1940 to 1970 period is projected to continue through 2020. Employment will experience a relatively faster rate of growth. Total employment is projected to increase 60 percent, and employment in the manufacturing sector is projected to increase 38 percent between 1960 and 2020. Per capita income, only 71 percent of the Basin average in 1962, is projected to reach 91 percent of the Basin average by 2020. Total personal income is projected to increase at an annual rate of 3.6 percent, which is below the Basin and national rate of 4 percent. In 1970, only 39 percent of the population was classified as urban. Projections show that in 2020, agriculture will employ only 3 percent of the work force. In 1970, it employed 8 percent. This factor, along with some increase in the total population of the area, should increase the degree of urbanization.

PROBLEMS NEEDS AND OPPORTUNITIES

An analysis of the problems, needs and opportunities along with their precise definition provides the basis for formulation of alternatives to satisfy those problems and needs. The problems, needs and opportunities stated in this section are only those that are related to water and related land resouces management. They were identified through analysis of existing conditions, public input, and projected future conditions. Special attention is given to when in time the problems and needs exist. A considerable number of problems exist given existing conditions; however, they are, as explained under their respective heading, not considered to be within this study authority because of the intent of the resolution initiating this study. Additional problems and needs arise with respect to the most probable future condition, which was described in the previous section, and are considered under this study authority. Therefore, the basis for present and future needs rests heavily upon what is considered to be the most probable future condition.

a. Navigation.

(1) Capacity

Capacity can be defined as the maximum throughput (in terms of total annual tonnage) or processing ability (in terms of total annual vessel

transits) of a navigation system. The capacity of a navigation system (in this case the St. Lawrence Seaway) is determined by the system's most constraining element. Each element of the system (i.e. Welland Canal and St. Lawrence River locks) has unique physical characteristics which determine the capacitry of those elements.

For purposes of this study, these projections of annual tonnage and transits have been measured in terms of percent of time the existing locks are available to process vessels. The parameter is termed, percent lock utilization. Because there is no precise definition of capacity, in terms of percent lock utilization, a range of analysis approach was selected.

The range of percent lock utilization selected for the analyses in this report is from 80 to 90 percent.

Capacity is not considered as 100 percent utilization because it is unrealistic to assume, for instance, that with seasonal movements in one direction, turnback or lockages with no vessel would not result. In addition, it is unlikely that for every day and hour of the season there will be a vessel available to use the lock because of random arrivals.

Based upon existing conditions there is no problem with capacity at the St. Lawrence Seaway. However, considering the most probable future, capacity will be reached at the St. Lawrence Seaway between 1985-1992 (dates based on analyses for this study).

The remainder of this section on navigation problems discusses elements which tend to limit the capacity of the GL/SLS system within the U.S. portion of the St. Lawrence Seaway.

(2) <u>Lock Size</u>

Lock size can limit capacity by constraining vessel size in any one or all of their physical characteristics (length, beam, and draft). Vessels wishing to enter or exit the Seaway locks (Welland Canal and St. Lawrence River) are limited to a length of 730 feet, a beam of 76 feet, and a draft of 26.0 feet below low water datum (LWD). These limitations are imposed by the size of the locks on the Seaway except that draft is restricted equally by the controlling depth of the channels which is 27.0 feet below LWD, and the depth of the lock sills which is 30.0 feet below LWD (both considered sufficient for 26.0-foot draft).

Presently, the lock size limitations of the Seaway system do not limit the capacity. None of the locks in the system have reached 80 to 90 percent lock utilization, and the current fleet has a sufficient number of vessels which can transit the system and carry the required tonnage.

The lock size limitations do hinder efficient movement of commodities when economics of scale are being demonstrated in the world fleet in the Great Lakes fleet. Larger ships are more efficient in relation to their size and as such are able to transport more cargo at a reduced rate per ton. The present size restriction is presently limiting the size of vessel which can

utilize the system. This not only limits the potential savings of the larger vessel but also the competitiveness of the Great Lakes in the world market. This is especially evident in view of the ever increasing size of ocean vessels in the world fleet.

In 1966, only three vessels in the world merchant fleet exceeded a length of 1,000 feet. By 1970, this had grown to 81 vessels, practically all tankers. However, in 1970, 99.9 percent of the freighters in the world fleet were under 700 feet. Thus, the limiting length (730 feet) of the Seaway locks is not a problem to ocean-going general cargo vessels, but does represent a problem for the larger dry bulk carriers, both laker and ocean-going types, which over the years have increased in the 700 to 1,000-foot range. Container ships are also expected to increase in length in the 1,000-foot range, and with the increased amount of container traffic on the Seaway, the locks will represent a limitation on their size.

In recent years an increase in vessel beam has characterized the new ocean-going fleet. The beam limitation of 76 feet posed by the Seaway locks is more critical to ocean-going fleet than is length. The beam limitation thus limits more and more of the ocean-going fleet which can utilize the Seaway. With the newer and more efficient vessels unable to utilize the system, the existing ocean-going fleet on the Seaway will be characterized more and more by older and less efficient vessels. This in turn mainfests itself by decreasing the competitiveness of the Seaway in world trade. The beam limitation is most important to containerships and ocean-going bulk vessels. Most of the conventional breakbulk or general cargo (98.1 percent in 1970) have beams less than 76 feet and thus are not severely limited.

There is also a trend towards deeper draft in the world fleet, similar to the trends in beam and width. The present draft limitation of approximately 26 feet within the Seaway is extremely limiting to ocean vessels and to the Great Lakes fleet where approximately 40 percent of the vessels could utilize additional draft. Also, at least one Great Lakes vessel has ability to use 34 feet of draft. Again, this does not restrict the capacity of the system, but it does constrain efficient use of the system by disallowing economics of scale.

The Seaway lock size limitations in the future will not only impair efficiency within the lower system, but will also limit capacity. Considering the projected growth in commodity movements, the maximum carrying capacity of Seaway-sized ships, and the available time for lockages the St. Lawrence Seaway will reach capacity at the Welland Canal before 1995. Although the St. Lawrence River locks do not reach capacity until several years later, the lower system must contain a consistent set of improvements. For example, if the Welland Canal is improved with a new series of locks larger than Seaway-sized, the "constraint" in the lower system will be the St. Lawrence River locks. This is because the larger vessels can now pass through the Welland Canal increasing its capacity, but they cannot pass through the St. Lawrence River locks. If duplicate "Seaway-sized" locks are added to the existing locks at the Welland Canal, the St. Lawrence River locks will not immediately become the lower system constraint. Instead, as tonnage and transits on the St. Lawrence River increases they will eventually reach their

capacity, and after the nonstructural to maximum utility concept is utilized, they must be improved with duplicate locks as the Welland Canal was improved earlier. Actually, the U. S. locks in the St. Lawrence River are not considered to be the constraining locks in the subsystem, but again, system and subsystem compatibility is assumed to be maintained.

(3) Lock Processing

Besides being constraints to throughput because of vessel size limitations, locks can be limiting due to mechanical capability and operating procedure. The mechanical capability and operating procedure determine the ability of the lock to process a number of vessels during a given amount of time which in turn establishes the capacity of the lock. The locks are not presently constraining the system due to any mechanical capability or operating procedure although individual vessel operations may be constrained. Individual vessel problems are not, however, a part of this study's concern.

In the future, given increasing vessel traffic demand, processing time and efficiency could be limited by:

- lockage of smaller ships which does not completely fill the lock and wastes "lockage space" which larger ships could utilize to transport additional cargo (tons per transit).

- lockage of ships which do not carry cargo (ballasted transits) and occupy useful space in a lock or may require separate lockages which could otherwise be used to process ships transporting cargo.

- lockage of ocean ships decreases the average tonnage per lockage when compared with lake ships because ocean ships generally carry fewer tons per transit at the restricted Seaway draft. They are also slower and harder to maneuver in restricted areas, requiring an increase in lock processing time.

- lockage on a first-come-first-serve basis which causes turnback.

- lack of traffic control system which may hinder efficient ship arrivals (staging) thereby lengthening waiting times and decreasing the theoretical possible number of lockages.

- limited lock dump/fill capability (constrained by the locks hydraulic system).

- limited ship speed on lock entry and exit (safety for the ship and lock).

- problems with ship positioning and staging to gain entry to locks with inadequate approach walls.

In time, these limitations on processing time and hence, efficiency will become significant, and limit the capacity of each individual lock and therefore the system. The slowest lock in the system will constrain the entire system.

(4) Channels

The channel depth must be sufficient to provide for the vessel draft and a phenomenon known as "squat." This is actually a lowering of water level around and behind a vessel. This causes the vessel to lie lower in the water than the surrounding undisturbed water. The present 27.0-foot channels allow a maximum draft of 26.0 feet, thus allowing one foot for this squatting of the vessel. This 26.0-foot draft restriction imposed by the Seaway channel is the most severe of the channel size restrictions. In 1969, less than half (47.5 percent) of the total world fleet, and in 1970, only 58 percent of the total world freighter fleet, had a usable draft greater than the permitted 26.0 feet. In 1976, 66 percent of the ocean-going vessels using the Seaway were restricted from using their full available draft by the depth of the channels and locks. Though draft is not an absolute restriction, since vessels can vary their loading, it does restrict optimal use of the vessels. This is an important factor in determining transportation rates, and thus in competing with other trade routes.

Currently the channels do not limit the capacity of the system. In the future, based on increasing traffic, the channels could be a restraint on the draft of vessels if any new locks allow for some increase in draft thus making the channels the limiting factor.

(5) Currents

Currents present a problem to navigation in a couple of areas including Copeland Cut, Galop Island, and Ogden Island. With the creation of Lake St. Lawrence by construction of the Moses-Saunders Power Dam and control works the previous river valley was flooded. The navigation channels, requiring as straight a course as possible, were constructed across what had been bends in the river. The old river channel still carries the majority of the water, and where this channel crosses the navigation course, cross currents are present. The cross currents tend to push the vessel out of the navigation channel which could result in grounding of the vessel or possible collision. This may result in a delay to the vessel or possibly halt navigation altogether until the channel can be cleared. This can be a very critical problem when the vessel is approaching a lock where control and maneuverability are essential. This is a problem more of an operational nature and not covered under the present study authority since no significant pattern of groundings or accidents were observed.

(6) Climate

Climate has both short- and long-term impacts on navigation. Long-term impacts of climate are on water levels and flows and upon ice formation. Long-term fluctuations in the amount of precipitation affect the water levels and flows. Water levels and flows on the St. Lawrence River are in response to the control of the Lake Ontario outflows at the Moses-Saunders Dam. Control of Lake Ontario outflows is based upon precipitation and subsequent inflows. When a high water level is observed on Lake Ontario, as has been experienced in recent years, larger amounts of water have to be discharged into the St. Lawrence River which raises levels and flows and increases

velocities within the navigation channel. This increased discharge from Lake Ontario results in a decrease in speed for upbound vessels and a loss of controlability for downbound vessels.

Another long-term impact of climate is ice formation, which closes the Seaway from about 15 December to approximately 1 April. During the 3-1/2 winter months that the Seaway is closed to navigation, money is lost as large fleets of expensive ships and dock facilities are immobilized, crews and longshoremen are unemployed, materials have to be stockpiled, and cargoes are rerouted to other modes of transport. General or break bulk cargo is particularly sensitive to this latter impact. Few, if any, ocean ships stay in the system during the winter closure.

Weather conditions such as wind, rain, snow, and fog are short-term effects of the climate. The wind generates waves which in some cases can cause difficulty in the controlability of vessels. Rain, and more so, snow and fog, are weather conditions which affect visibility severely, especially in confined channels, sometimes halting navigation for days. Snow of course is limited to the colder months of the navigation season, during early April, November, and December. It is also during November and December that the St. Lawrence River experiences its problems with fog. The water of the St. Lawrence River, having come from Lake Ontario, is warmer than the air. This causes fog which may last for days, although generally it is only a problem during the night and morning hours. These delays, again, equate to loss in transit time and reflect as a loss to the shipper. Therefore, short-term effects of climate can be a limiting factor to capacity.

(7) Erosion and Shoreline Damage

Erosion and shoreline damage to structures such as boat docks and fishing piers are partially attributed to vessel-generated waves. Areas of concern are erodible shoreline areas in downstream reaches and areas with narrow channels resulting in a close proximity of shore structures to the navigation channel. Additional potential problems occur during the later part of the navigation season when ice adheres to shore structures. Wakes of passing vessels can cause the ice to uplift resulting in piling and dock supports being pulled out. In some areas, speed limits are imposed to reduce the wakes of passing vessels. These speed limits equate to an increase in transit time.

Wakes of vessels are not the only cause of erosion and shoreline damage. A complete study of erosion and shoreline damage is being performed under the Lake Ontario-St. Lawrence River Shoreline Protection Study (LO-SLRSPS) authority. This study will be fully coordinated with the LO-SLRSPS and the results of that coordination incorporated into this study.

(8) Other

Other elements affecting capacity include pilotage, navigation aids and recreational boating. Delays sometime occur while vessels are required to lie at anchor until a pilot becomes available. Safe operations of vessels are sometimes hampered because of limited channel markings. Recreational

boating traffic in locks may delay lockage of commercial vessels. These elements affecting capacity are operational problems and determining their solution is not covered by the present study authority.

b. Environmental and Socioeconomic.

The communities along the St. Lawrence River depend on the river heavily for their livelihood. The whole region, except for a few isolated industrial centers is centered around the St. Lawrence which provides numerous forms of recreational activity, and is the basis for a high percentage of the local income. Presently, there appears to be a workable medium reached between the New York State Department of Environmental Conservation (NYSDEC), local residents, shippers, and the Seaway authority, but anything that could offset this balance is considered by the river populus to be very detrimental. Proposed changes are met and viewed with much skepticism.

The St. Lawrence River is noted for its fishery - especially its sportfishing. Species like smallmouth bass, largemouth bass, perch, pike and the highly prized muskellunge, attract sportsmen and vacationers. This influx of people utilizes local motels, campgrounds, boat liveries, restaurants, stores, etc., and provide a spur to this area's economy for approximately 5 to 6 months a year. Seasonal income, based on recreational or environmental activity centered around the river, is essential to this area. The Akwessasne Mohawk Indians, many of which follow off-reservation steel construction a good part of the year and return to the reservation duing the winter, depend on trapping along the river marshes as an important supplement to their income during the off-season, is a prime example. In general, residents in the vicinity of the river are very concerned with changes or modifications to this waterway, whether it be physical changes as dredging, operational changes as extension of the navigation season, or altering the present capacity of the system - either by allowing larger ships to navigate the system, or by increasing the number of ship transits. Any change that could destroy, alter, or adversely affect the fishery, wildlife, scenic quality or recreational value of the river is of the utmost concern not only to this region's residents but also to NYSDEC and the U.S. Fish and Wildlife Service (USF&WS). Therefore, a need of this study must be to further identify impacts to existing important resources located throughout the Great lakes System - especially in the St. Lawrence River - and to minimize or mitigate significant adverse impacts so that the ecosystem of the St. Lawrence River is not significantly upset. In addition, any measures that can enhance recreational opportunities that are compatible with the existing ecosystem of the river, should be pursued and considered.

c. Erosion and Shoreline Damage.

Erosion and shoreline damage was covered earlier under Navigation Problems but this section is to highlight that erosion and shore damage problems are not only associated with vessel-generated waves. With the construction of the Seaway and creation of Lake St. Lawrence along with an accompanying rise in water surface elevation, the shoreline and to some extent the lake bottom is now composed of erodible soil. Erosion of the shoreline can be attributed to wind generated waves currents, and vessel

generated waves. The degree and severity of each is not known at this time but is the subject of studies proposed under the Lake Ontario-St. Lawrence River Shoreline Protection Study.

d. Summary.

Although the study authority limits the investigation to the needs of present and future commercial navigation, it is important that the study also be cognizant of other resource problems, needs, and opportunities. The study will attempt to identify and solve other resource problems and needs as best it can in formulating plans for commercial navigation. Where the study is unable to solve or only partially solve other resource problems, it will make every attempt so as not to aggravate them.

## NATIONAL OBJECTIVES

The national objectives for planning water resources projects are set forth in the Water Resources Council's "Principles and Standards for Water and Related Land Resources Planning." The two national objectives are to enhance national economic development (NED) by increasing the value of the nation's output of goods and services and improving national economic efficiency, and to enhance the quality of the environment (EQ) by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. Later the alternative plans are evaluated as to their achievement of these two objectives, vis a vis their relative contributions to the respective accounts.

## PLANNING OBJECTIVES

Planning objectives are extracted from national, state, and local water and related land resource management problems and needs. These are specific to a given study area, and can be addressed to enhance National Economic Development or Environmental Quality. Planning objectives provide a means of bridging the gap between the universality of the two national goals and the specificity of the problems in a given area. While it is not always possible to directly plan for enhancing NED by increasing the value of the Nation's output of goods, and improving national economic efficiency, it is possible to contribute toward these needs and NED. The same can be said for contributions to EQ.

The purpose of planning objectives is to provide sufficient specificity to direct the study in a meaningful manner. These objectives will be used to guide the formulation of alternate plans. They are also used in evaluation, when it is necessary to determine the degree to which each plan fulfills the requirements of each objective as a basis for reiteration. Generally, they will become more precisely defined as the study progresses through subsequent planning stages.

The planning objectives have been developed to address the problems, needs, and opportunities along the U. S. portion of the St. Lawrence Seaway within a 70-year period of analysis (1980-2050). The objectives address the resources

within the context of the purpose and intent of the study authorization and address other related resources of the St. Lawrence River and its shoreline. The objectives will be used to refine the formulation of alternate plans such that the plans are responsive to as many other resource problems as possible with a view to optimizing contributions to NED and EQ.

The plan objectives for the St. Lawrence River Additional Locks and other Navigation Improvements Study are as follows:

. Provide for equitable regulation of lake and river levels so as to minimize total adverse impacts of fluctuation in supply conditions, taking into account costs to power, navigation, shoreline development, and the natural resource base.

. Preserve or enhance water quality to the extent necessary for continued productivity of aquatic biological resources.

. Promote regulations governing treatment and discharge of sewage and other wastewaters from commercial and recreational vessels.

. Provide for disposal of any dredged material in a ecologically satisfactory manner. Federal regulations concerning discharges of dredged material into navigable waters from Federally-funded projects have been promulgated by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps). Federal regulations also control projects involving the discharge of dredged or fill material into navigable waters from private entities. Federal permit to discharge dredged material into navigable waters of the United States (Section 404 permit) is required for dredging activities. This permit is issued by the Secretary of the Army as required by Section 404 of the Clean Water Act, even though it is Corps who is managing the project. The issuance of such a permit is considered to be a "major action" and therefore, an Environmental Impact Statement must be written to fulfill the requirements of the National Environmental Policy Act (NEPA) of 1969. NEPA requires that Environmental Impact Statements be composed for all activities which are considered to be "major actions." States must also provide Section 401 certification that the proposed project will not violate State water quality standards. Other Federal regulations which must be considered for legal disposal of dredged material are those associated with the Clean Water Act and the Resource Conservation and Recovery Act. The Clean Water Act directed the institution of the National Pollutant Discharge Elimination System (NPDES) throughout the United States. Authority to administer NPDES has been delegated to the States. Wastewater associated with dredging activities (i.e., leachate, runoff, and elutriate from upland disposal areas) must be treated and discharged according to State regulations. Permits may be required for upland disposal sites in order to discharge any wastewater eminating from the dredged material. A final Federal regulatory program currently in the process of being delegated to individual States for administration is the Resource Conservation and Recovery Act. This Act is intended to control the safe and environmentally sound disposal of nonhazardous and hazardous solid waste. Upland, confined disposal of dredged material and certain other disposal scenarios (e.g., diked disposal in navigable waters) may be subject to State solid waste regulations.

. Provide for use and management of shorelands and tributary uplands in ways that reflect the normal processes of change affecting shoreline natural resources (such as marsh eutrophication and shoreline erosion) and that entail minimum interference with those natural processes.

. Protect the scenic value of natural areas as a significant ingredient of the recreational environment.

. Provide for control and limitation of public access to critical natural resource areas on the shoreline to prevent avoidable damage to fragile plant communities, loss of highly erodible soils, and disturbance of seasonally critical wildlife habitat, such as shorebird wintering areas.

. Maintain and/or increase the opportunity for recreational use of the St. Lawrence River consistent with the area's resources.

. Protect and enhance the scenic and aesthetic resources of the basin.

. Protect historical, archeological, and other public interest areas.

. Enhance the economic vitality of the Great Lakes-St.Lawrence River Basin.

. Promote the efficient use of the present Great Lakes-St. Lawrence Seaway system in terms of tonnage moved and vessel transits.

. Promote efficient utilization of the navigation infrastructure of the Great Lakes-St. Lawrence Seaway system.

. Contribute to an increase in output of goods, services, and external economics of the Great Lakes-St. Lawrence Seaway system.

. Contribute to the maintenance of the required water levels of Lake Ontario and of flows for the St. Lawrence River.

. Contribute to the quality of the Great Lakes-St. Lawrence Seaway environment, and water quality of the lakes.

As the study progresses, these planning objectives will be continuously reanalyzed and refined as new problems and needs are identified or regional objectives change. The planning objectives will then develop into objectives which are more resource and site specific. Each plan, which is formulated in subsequent stages of the study, will be evaluated as to whether and how well it addresses these objectives. Although a plan satisfies one or several objectives, it may in fact worsen conditions relative to another objective. The evaluation of plans will serve to identify tradeoffs, in both monetary and nonmonetary terms, which would be necessary for a particular plan to be implemented. The identification of these tradeoffs will also serve in reformulating plans in subsequent study efforts to minimize negative impacts relative to other objectives.

## PLANNING CONSTRAINTS

Constraints, both directly and indirectly related to the NED or EQ objectives, are important planning considerations, and direct the plan formulation process. The constraints identified for this study are:

a. The technical limits for vessel size in terms of draft, beam, and length;

b. The effects of large vessels on the environment, both natural and human;

c. The dependence or independence of improvements on the Lower Great Lakes subsystem on the Upper Great Lakes portion of the system;

d. The availability and suitability of disposal sites to contain materials dredged for construction and maintenance of proposed alternatives;

e. The realization of legal and international aspects of enacting modifications to the Lower Great Lakes subsystem; and

f. Recognizing that the planning for this study must take place on a unilateral basis. Formal coordination with Canada will not be permitted for this feasibility level study until the U.S. interest is determined.

## PLAN FORMULATION

### STUDY ASSUMPTIONS

There are a certain number of assumptions that are necessary to conduct any type of planning study. They generally tend to simplify the analyses, and help the analyst focus in on the problem being studied. The Great Lakes/ St. Lawrence Seaway system encompasses both the upper and lower portions, as has previously been discussed. The assumptions made for this study are broken into: Systemwide assumptions and lower system assumptions.

a. Systemwide.

The assumptions that apply to the upper and lower portion of the system are presented below along with the reason for their use:

• The Improvement Has a 50-Year Economic Life - This assumption is used for most water resources project analysis.

• Systemwide Traffic Forecasts Were Developed and Utilized for This Study - This assumption is used because of the integration of current system movements (i.e., a large portion of the movements utilize two and three lock node movements.

• This Study Will Develop and Present Only U.S. Benefits and Costs - This assumption was used since rate studies only looked at the U.S. rate differential, and the Canadian rate differential may differ greatly because of the different transportation policies in the two countries.

• The Maximum Vessel Size to be Considered in this Study is 130 Feet Wide by 1,200 Feet Long Drafting 30 Feet - This assumption was used because the Maximum Ship Size Study (1977) identified this vessel size as the maximum vessel which could economically operate on the GL/SLS sytem.

• Current Two-Way Vessel Traffic in Connecting Channels would be maintained. This assumption assures that the channels will not become a system constraint, and provides a larger degree of safety for vessels operating in the system.

• The Base Condition Navigation Season Length is as Shown -

| Lock Node | Season | Months |
|---|---|---|
| Soo Locks | 1 April - 8 January ± 1 week | 9-1/4 |
| Welland Canal | 1 April - 31 December | 9 |
| St. Lawrence River | 1 April - 15 December | 8-1/2 |

This assumption is based partly on historical data, and the current established length of operating season.

• The Existing Levels and Flows Regime of the GL/SLS System is Maintained - This assumption is used to insure the proposed improvement do not effect the other user interests in the GL/SLS system (i.e., riparian, recreational, and power).

• The Existing Locks Will Operate for the Economic Life of the Project - This assumption is made to maximize use of the existing system, and is engineeringly feasible.

• Coordinated Structural Improvements - This assumption insures that both the upper and lower systems and all Canadian and U.S. improvements will be compatible.

b. Lower System.

The assumption shown below apply specifically to this study of the lower portion of the GL/SLS system, and they are used in the analyses for this report. The assumptions and the reason for using them follow:

• The Maximum Length of Navigation Season to be Considered for the Lower System is 10 Months - This assumption is consistent with the Board of Engineers for Rivers and Harbors review of the Navigation Season Extension report. The analysis of this assumption will be limited to sensitivity testing and represent a "no cost" (to this study) alternative plan to extend capacity of the lower system.

• Nonstructural Improvements are Assumed to be Implemented When Needed by the Operating Agency of the Locks Reaching Capacity - This assumption is consistent with the current procedures for the U.S. (St. Lawrence Seaway Development Corporation) and Canadian (St. Lawrence Seaway Authority) operating agencies.

• The Welland Canal is the Current Systemwide "Constraint" - This is accepted by the operating agencies, users, and analysts of the system. This is because of its location between the other two locks, its physical configuration, and the GL/SLS system commodity flow patterns.

• The Canadians Will Improve and Expand Their Facilities When Capacity of Those Facilities is Reached - As discussed above, the Welland Canal is the current "constraint" in the lower system. If this constraint is not removed, the U.S. locks in the St. Lawrence River will theoretically never reach their capacity, and there would be no need for a study of them. The resolution for this study is explicit, and therefore this assumption is made.

• All Improvements in Canadian Territory are Made at No Cost to the U.S. - This assumption is also included in the systemwide listing, it is necessary due to the method of analysis used, and is consistent with the existing GL/SLS system facilities and level of investment.

• The Current Number of Locks in the System Would be Reduced With Any Replacement Scenario - The trend of system improvements is to reduce the number of locks in the system. All improvement plans to date by the Canadians call for a reduction in the total number of locks.

• The U.S. Will, as a Minimum, Maintain Their Present Level of Investment in any Future Improvement Scenarios - This assumption is consistent with the existing locks and navigation channels in the St. Lawrence River.

c. U.S. Costs.

The U.S. costs are defined as:

(1) The costs of building and maintaining any new locks to replace or augment the Eisenhower and Snell Locks.

(2) The costs of building and maintaining all navigation channels in the U.S. portion of the St. Lawrence River, and

(3) Twenty percent of the systemwide harbor improvement costs as identified in the Connecting Channels and Harbors Study. The percentage was derived based upon system movements and the source of tonnages handled at individual harbors. The calculation of costs is described in Appendix D.

d. U.S. Benefits.

U. S. Benefits are assumed to be those transportation savings derived from any commercial commodity movement originating at or having destination of a U. S. Great Lakes harbor. Benefit determinations are calculated on the following basis:

. All savings on U. S. Great Lakes harbor to another U. S. Great Lakes harbor movements.

. All savings on U. S. Great Lakes harbor to foreign harbor movements.

. All savings on foreign harbor to U. S. Great Lakes harbor movements.

. One-half of the savings on all U. S. Great Lakes harbor to Canadian harbor and all Canadian harbor to U. S. Great Lakes harbor movements.

MANAGEMENT MEASURES

Formulation of alternatives starts from a list of measures or plan elements which satisfy the component needs identified in the problem identification section. Management measures considered in this Preliminary Feasibility Report on commercial navigation were divided into nonstructural and structural measures. Some measures were not considered in this study because they were already incorporated into plan elements during another study and they are covered in the section - Other Study Plans. The specific management measures investigated are listed below:

a. Nonstructural.

Generally, these are measures that result in increasing the capacity and/or efficiency of the existing lock system. This can be accomplished by

either changes in operating policy/procedures, or minor structural improvements in and around the existing locks to make them more efficient in processing ships. Measures 1 through 5 below involve the first category (i.e., changes in operating policy/procedures), 6 through 9 are examples of the second category (i.e., minor structural improvements), and measure 10 incorporates both of these concepts. These measures are:

( 1) N-up/N-down (number upbound equal number downbound);

( 2) Favor Cargo-Carrying Ships;

( 3) Favor Larger Ships;

( 4) Favor Lake Ships Over Ocean Ships;

( 5) Implementing a Congestion Toll;

( 6) Install Traveling Kevels;

( 7) Increase Ship Speed Entering the Locks;

( 8) Decrease Lock Chambering Times;

( 9) Install a Traffic Control System; and

(10) Extend the Navigation Season.

b. Structural.

Generally, these are measures requiring major construction. These measures are:

( 1) Deepen Navigation Channels; and

( 2) Build New Locks.

## FORMULATION AND EVALUATION CRITERIA

The formulation and evaluation of alternate plans is done within the context of the planning objectives (described earlier), and technical, economic, environmental and socioeconomic, and institutional criteria described in this section of the report. These, and other intangible considerations, permit the development of a range of feasible and justifiable plans which best respond to the problems and needs of the area.

a. Technical Criteria.

( 1) The maximum ship size for consideration on the St. Lawrence Seaway is 1,200 feet long with a beam of 130 feet. This is based on the conclusions reached in the Maximum Ship Size Study.

( 2) The maximum allowable ship draft for consideration on the St. Lawrence Seaway is 30 feet below low water datum. This is based on a similar restriction in the connecting channels to maintain existing levels and flows.

( 3) The base condition length of navigation season on the Welland Canal is assumed to be 9 months, and the St. Lawrence River is assumed to be 8-1/2 months. The maximum probable length of the navigation season in both areas is assumed to be 10 months.

( 4) Alternative plans must be engineeringly feasible, practicable, and they should expand the capacity of the system by the desired amount.

( 5) Structural plans will be adequate to provide a project life of 50 years.

( 6) Alternative plans should be compatible with, and not preclude, any similar plans in the Upper Lakes portion of the Great Lakes/St. Lawrence Seaway System.

( 7) Existing facilities will be utilized to the maximum extent possible. This includes modifications to these facilities.

( 8) Resultant flows of the St. Lawrence River from any plan of improvement must meet with criteria established by the Orders of Approval for the Regulation of Lake Ontario and Downstream Physical Constraints and subsequent Plan 1958-D for the regulation of Lake Ontario.

( 9) Additional navigation facilities will minimize water usage so as to cause the smallest possible reduction in power generation.

(10) Construction techniques will not impair the use of the system.

b. Economic Criteria.

The economic criteria which are applied in formulating and evaluating a plan are as follows:

( 1) Tangible benefits exceed project economic costs to produce positive net benefits.

( 2) Each separable unit of improvement provides benefits at least equal to its cost.

( 3) The scope of the development should provide the maximum net benefits (benefits minus costs); however, intangible considerations could dictate a project which would forego a relatively small percentage of net benefits.

( 4) There should be no economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This limitation refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the project were undertaken. The plan

resulting from application of the foregoing criteria provides a baseline for consideration of the numerous other factors which are not reflected in quantifiable economic terms, but which may warrant modification of the plan. An example would be an alternate water transportation route which could be utilized more economically.

( 5) Benefits will be derived from a comparison of the projected "without project" conditions to the projected "with project" conditions for each plan.

( 6) Intangible benefits will be identified and evaluated in qualified terms, where possible, and will be included in the Evaluation Section.

( 7) The costs for alternative plans of development will be based on preliminary layouts, estimates of quantities, and price levels current at the time the estimates were prepared (for this analysis, March 1982 price levels are used).

( 8) The benefits and costs should be in comparable economic terms to the fullest extent possible. Annualized costs and benefits for the project life will be used.

( 9) The plan should enhance the economic vitality of the Great Lakes-St. Lawrence River Basin.

(10) The plan should approach or exceed an economic project life of 50 years, given the forecasted traffic levels used in this study.

c. Environmental and Socioeconomic Criteria.

( 1) Maintain and/or increase the opportunity for recreational use of the St. Lawrence River Basin consistent with the area's resources.

(2) Plans should minimize and, if possible, avoid destruction or disruption of community cohesion, injurious displacement of people, and disruption of desirable community growth.

(3) Protect historical, archeological, and other public interest areas.

(4) Investigate system design alternatives which would decrease the chances for an oil or toxic substance ship spill.

(5) Plans should maximize the beneficial and minimize the adverse effects of the project on man-made resources, natural resources, and air, water, and land pollution.

(6) Plans should avoid detrimental environmental effects to the fullest extent feasible. Unavoidable adverse environmental impacts should be fully noted, analyzed quantitatively when possible and qualitatively when not, so that knowledgeable decision making would be possible and feasible mitigating features for such effects can be included. This will involve utilizing all available information on fish and wildlife.

(7) A plan is acceptable only if it is supported by some significant segment of the public. Every attempt will be made to eliminate, to the extent possible, unacceptability to any significant segment of the public.

d. Institutional Criteria.

(1) All plans should be designed to be fully compatible with Canadian plans, and the remaining U. S. portion of the Great Lakes/St. Lawrence Seaway System. Planning should take place on comparable levels in both countries.

(2) Timing of construction should be compatible with Canadian plans.

(3) Costs are assumed to be apportioned by their physical location (i.e., U. S. costs are derived from plan components located within U. S. territory, and Canadian costs are dependent on the plan components located within Canadian territory).

(4) The national security of the United States should be maintained or enhanced by any decision recommended by this study.

(5) The safety and reliability of system operation should be maintained or enhanced.

## POSSIBLE CONCEPTS FOR INCREASING CAPACITY

a. Development of Concepts.

Management measures identified earlier were considered separately or in combination, to form concepts which address the problems and needs. Concepts are more refined than measures, but are not as detailed as plans. Concepts take into account some of the variability associated with measures or combinations of measures, but do not assign specific dimensions.

The concepts discussed here were formulated in light of the planning objectives developed for the study and the various technical, economic, environmental and socioeconomic, and institutional criteria and constraints that have been identified thus far in the study. As possible solutions to the problems identified in this study, the following structural and nonstructural concepts were identified during the initial phase of this Preliminary Feasibility Report. Alternative plans were developed from these concepts; and then they were evaluated against the "without project" conditions described previously in this report.

Seventeen concepts and a description of each is presented in this section. After identification, they are given an initial screening with the rationale given for elimination of a portion of these concepts. The remaining concepts are used to develop plans that will be analyzed in the next portion of this Preliminary Feasibility Report.

- Concept 1, N-up/N-down - This is one ship up and one ship down lock sequence. The implementation of a 1-up/1-down policy would use the effort required to turnback a lock (i.e., dumping or filling) to transport a ship

traveling in the opposite direction before a second ship traveling in the first direction would be locked through. The 1-up/1-down policy would increase capacity only when queues exist on both sides of the lock. The direct benefit would be that a vessel would be transported through the lock in every lockage. Where a portion of the system could not accommodate two-way traffic, some channel widening would be required.

- Concept 2, Favor Cargo-Carrying Ships - For this concept, priority is given to loaded ships. Ships which do not carry cargo occupy useful space in a lock or may require separate lockages which could otherwise be used to transport cargo. The effects of pleasure craft on lock capacity could be minimized by providing separate facilities to transit the pleasure craft, locking pleasure craft only at set times of the day, or by giving pleasure craft low priority when there are cargo ships waiting. Ships in ballast might also be given low priority when loaded ships are waiting. This would encourage cargo carriers to take loaded backhauls.

- Concept 3, Favor Larger Ships - In an effort to increase the tonnage transported in each lockage, preference would be given to larger ships. Two methods of implementing this measure would be to give larger ships priority at the locks or to change seaway tolls so that larger ships would be charged at a lower rate per ton of cargo than smaller ships. This would encourage a change in fleet mix and new ship construction tending towards larger ships.

- Concept 4, Favor Lake Ships Over Ocean Ships - Changing the toll structure to discourage ocean-going ships from entering the Great Lakes/St. Lawrence Seaway System could increase lock capacity. Ocean-going ships which operate through the system generally do not carry as much cargo as the lake ships; therefore, more tonnage is transported per lockage on the average with lake ships (a larger percentage of lake ships are designed to optimize tons carried at the current system draft). Ocean ships are also generally slower and harder to maneuver into and out of the locks, expecially in the Welland Canal and St. Lawrence River, and therefore require more time to lock through.

The implementation of a new toll structure would make it more economical for the ocean ships to put in at Quebec City or Montreal where they can use their deep draft design. Cargo would be transshipped to and from these points by lake ships designed to operate more efficiently through the locks.

- Concept 5, Congestion Tolls - This measure would involve additional changes to the existing toll structure which would, in effect, favor high value per tonnage commodity shipments over lower value commodity shipments. Tolls would be adjusted in such a way that it would become more economical to transport the lower value cargo such as grain via other systems (e.g., rail). Therefore, the system would be able to lock through a larger volume of higher value cargo (e.g., iron ore) by forcing lower valued commodity movements to an alternate transportation mode.

- Concept 6, Install Traveling Kevels - Traveling kevels are wheeled movable mooring posts which would travel on a rail along the guide walls on both sides of the lock. Upon approaching the lock entrance, a ship would be

moored to the kevels. The kevels would then tow the ship into the lock. A ship under its own power must proceed into a lock very slowly to minimize the chance of damaging the lock or the ship. Using traveling kevels, it is estimated that a ship would be able to move into the lock faster with the same degree of safety. Ship speed entering the lock would increase, decreasing locking time (time required to process a vessel through a lock). Some of the time gain, however, would be lost on the hook-up and release process.

. Concept 7, Increase Ship Speed Entering the Locks - To implement this alternative, ships would be instructed to enter the locks at a higher speed. The ship would have to rely to a greater extent on the operation of its own controls, particularly the application of reversal of power. Additional safety procedures and devices would be implemented at the lock to reduce the chance of lock and ship damage. Safety devices may include replaceable fenders, energy absorbers, and rolling fenders. Some of these devices are currently in place at the St. Lawrence River Locks.

. Concept 8, Improve Hydraulic System Capability - Chambering time is the time required to close the rearward gate, empty or fill the lock, and open the forward gates. Locking time could be reduced by reducing the chamber dump/fill times, and decreasing the amount of time required for the ship to exit the lock chamber. To reduce the dump/fill time, the hydraulic system of the lock would be remodeled or replaced. The flow rate through the culverts and the intake and outlet ports would be increased. The culverts would be increased in size and the valves would be modified to open and close faster. Self-cleaning trash racks would be installed to prevent blockage of the water intakes.

. Concept 9, Alter Hydraulic System so as to Assist Exit Speed - Exit times could be reduced by providing longitudinal hydraulic assistance for ships exiting locks downstream. Water would be allowed to enter the chamber through the filling ports from the upstream side to hydraulically assist the exit of downbound vessels. Additional coordination between the lock operator and ship's captain would be required. Implementation of this alternative would decrease the lock chambering time.

. Concept 10, Traffic Control System at Locks - The proposed traffic control system would consist of a central, computer-run control point for the lock system. Information concerning all of the ships approaching or in the lock system would be input. The system would plan ship arrivals at the locks to reduce lock approach times. Ship meetings at restricted channel sections would also be reduced by use of this system to increase safety. Instructions would be relayed to the ship captains by radio from lock traffic controllers at the central control station. The proposed traffic control system would be designed to reduce delay in lock approaches and would allow faster responses by the lock operators in the locking operation.

. Concept 11, Nonstructural Improvement to Maximum Utility - The term Nonstructural Improvements to Maximum Utility refers to the combination of the preceeding nonstructural measures selected in a way that shows potential for providing the greatest increase in lock system capability. The

combination of measures accounts for mutually exclusive contributions to lockage time reductions.

The locking operation can be considered as a series of discrete events, each of which requires a certain amount of time to perform. Each of the last five mentioned nonstructural measures reduces the time it takes to perform one event. Either traveling kevels or increased ship speed reduce the entrance time. Reduced dump/fill times and downstream logitudinal hydraulic assistance decrease chambering time. The traffic control system reduces approach time.

Traveling kevels provide the largest capacity increase of all the individual nonstructural alternatives and, therefore, were included in this composite concept. Since the ship entering and exiting the lock would be under the control of the traveling kevels, the measures for increasing ship speed into the lock and downstream, longitudinal and hydraulic assistance are excluded because they do not provide additional independent contributions towards the reduction of lockage time.

The three nonstructural improvements of traveling kevels, reduced dump/fill times, and traffic control systems are independent and may, therefore, all be implemented as one composite plan. Since each reduces a different component of the time required to lock a ship, their locking time improvements are additive. The combination of these three improvements have, therefore, been selected as the concept which would attain maximum utility of nonstructural measures at the St. Lawrence Seaway.

. <u>Concept 12, Extension of the Navigation Season</u> - The implementation of season extension would tend to increase capacity by allowing ships to operate in the system for a longer period of time. A description of this concept includes both the need for changes to present operating policies/procedures and several minor physical modifications listed below:

a. Ice control structures (ice booms) in Great Lakes harbors and connecting channels;

b. Air bubbler systems in Great Lakes harbors and connecting channels;

c. Lock modifications and de-icing systems;

d. All-weather aids to navigation, including LORAN-C radio navigation and a system of fixed light structures, some of which would be equipped with radar transponder beacons and radar reflectors;

e. A weather and ice data dissemination system, including aircraft reconnaissance, ice reports, and ice and weather forecasts and advisories;

f. Emergency position indicating radio beacons for all vessels;

g. An automated vessel reporting system to coordinate vessel movements to form convoys and dispatch needed ice breakers;

h. Adequate ice breakers and icebreaking tug support;

i. Shipbuilding standards to insure the structural stability of ships operating in winter conditions;

j. Adjustment of speed limits to minimize shoreline erosion and property damage, if necessary;

k. Further improvement in the ability to handle oil or toxic material spills;

l. A comprehensive training program for Vessel Captain/Pilot Training; and

m. Mitigative measures (structural or compensation) for land and structure damage.

n. Provide cross channel transportation mitigative measures, as required.

- Concept 13 - Deepen the existing navigation channels to the maximum extent that is compatible with the existing lock design (i.e., 30.0 feet).

- Concept 14 - Build a larger lock(s) to replace the existing locks and widen navigation channels (based on ship beam), but do not deepen the system.

- Concept 15 - Build a larger lock(s) to replace the existing locks, and widen and deepen the existing navigation channels (up to 32.0 feet).

- Concept 16 - Build a twin (same size) lock(s) to operate simultaneously with the existing locks (a parallel system). No channel deepening or widening is required except near the new lock(s).

- Concept 17 - Build a larger lock(s) to operate simultaneously with the existing locks (a parallel system). Channel widening would be required to accommodate the larger ship's beam.

b. Initial Screening of Nonstructural Concepts.

The first five concepts in this category (Concepts 1-5) involve changes in current operating policy. Since the Seaway's opening in 1959, operating policies have been set and enforced by both the St. Lawrence Seaway Authority (Canadian) and the St. Lawrence Seaway Development Corporation (American). Therefore, implementation of any operating policy by the Corps is infeasible; however, operation changes for subsequent implementation by the present operating agencies and operation changes incorporated as a part of the total plan were addressed in this study if they improved capacity. However, limited analysis of these concepts was performed because of the lack of methods to measure effectiveness and because they are not required at the Eisenhower and Snell Locks until something is done to significantly expand the capacity of the Welland Canal. When this happens, it appears the most likely improvement would involve larger locks, and necessitate the immediate

improvement of the St. Lawrence River Locks to ensure a compatible system. If operating policy concepts were utilized, they would only be required at the Welland Canal, and, therefore, should not be considered as viable capacity improvement concepts for the U.S. portion of the St. Lawrence River. These nonstructural conceptual solutions have, therefore, been eliminated from further consideration.

The next five nonstructural concepts (Concepts 6-10) involve site-specific minor structural improvements. Concept 11 involves a combination of three of those five concepts for maximum utility. The effectiveness of those concepts was qualitatively analyzed in the ARCTEC Report, Sensitivity and Feasibility Analysis of Great Lakes/St. Lawrence Seaway Capacity Expansion Measures to the Year 2050 prepared for this report. Their effectiveness was found to be limited, and they, in themselves or in combination, cannot solve the capacity problem at any lock node.

Concept 11, the combination for maximum utility, can extend the date of capacity at the Welland Canal for about 10 years (an estimate arrived at through analysis for this report and verification from Canadian sources). While it could be effective at the Welland Canal by delaying the date of structural improvements, it is unlikely that this concept would be needed at the U.S. locks in the St. Lawrence River. The locks in the St. Lawrence River will not reach capacity because the Welland Canal constrains them once it reaches capacity. This is largely because of traffic patterns, and the close tie-in between the two sections of the Seaway, which was explained earlier under the Most Probable Futures Section. Figure 17 illustrates the interdependency of these two sections. If the Welland Canal is improved with larger locks, the St. Lawrence River Locks will become the constraint to the larger ship sizes which are expected to increase the system's capacity. Therefore, new larger locks would have to be constructed along the St. Lawrence River at the same time as the Welland Canal improvement. This construction would occur before any nonstructural improvements were implemented to increase capacity at the St. Lawrence River Locks.

Considering the above sequence of events, the only instance where any type of nonstructural improvements would prove helpful at the St. Lawrence River locks would be if the structural improvements at the Welland Canal were a parallel series of locks the same size as currently exists. This scenario would allow the St. Lawrence River Locks to reach their capacity and then utilize nonstructural improvements. This situation is analyzed, but is an unlikely future because of shipbuilding trends, economies of scale, and the position of the Canadians in preliminary design of new locks in their 1967 Feasibility Report. Only Concept 11 will be considered further because of the other's limited usefulness in expanding capacity at the U. S. lock(s) in the St. Lawrence River.

The last nonstructural concept (Concept 12) is extension of the navigation season. The concept involves changes in current operating policy/procedures, and some minor site-specific structural improvements. Giving the locks additional operating time is a measurable means of expanding capacity, and as evaluated in the Navigation Season Extension Report is engineeringly, economically, and environmentally feasible. However, this is probably the

most controversial subject on the Great Lakes/St. Lawrence Seaway System today. In addition, the Canadians have looked at this subject several times, and do not see the need for this concept at the present time. This does not preclude them from implementing this concept at some time in the future. This concept does require further study, and is included in the analysis presented in this report because it could be used in the future if, for example, it becomes necessary to temporarily increase the capacity of the system while a new system of larger locks is being constructed.

Concept 13 is the only structural concept which does not include a new lock configuration. Implementation of this concept could conceivably result in the deepening of the existing navigation channels from the present depth of 27.0 feet down to a maximum of 30.0 feet below LWD. At that point, the lock sills would constrain any further deepening and costly lock modifications would be necessary. This is not an effective solution from two standpoints: First, technically there should be a minimum of 4-5 feet of water under the ship being locked through; second, the locks cannot be taken out of service to make the required modifications; and thirdly, deepening the system to increase capacity appears to be more costly per ton of throughput than building larger locks and utilizing the existing draft. Even so, this concept was considered further for comparison purposes and its productivity will be compared to other improvement concepts.

Concepts 14 through 17, include a new lock configuration and are considered further for development into plans because they can expand the capacity of the St. Lawrence River portion of the seaway; and, they are suitable based on initial considerations for each of the technical, economic, environmental and socioeconomic, and institutional criteria presented in this section.

c. Initial Screening of Structural Concepts.

Initially the structural concepts requiring a new lock configuration for the U.S. portion of the system contained provisions for one lock or two locks. A brief analysis of the two possible ways of implementing a new lock configuration, two low-lift locks or one high-lift lock, was performed to consider this dual possibility. Either one high-lift lock can be constructed either north or south of the existing locks, or two low-lift locks similar in height of lift to the existing locks could be built in the proximity of the existing locks. Figure 19 shows the considered sites used for this study. There are advantages and disadvantages of both possibilities, these are briefly summarized in Table 7.

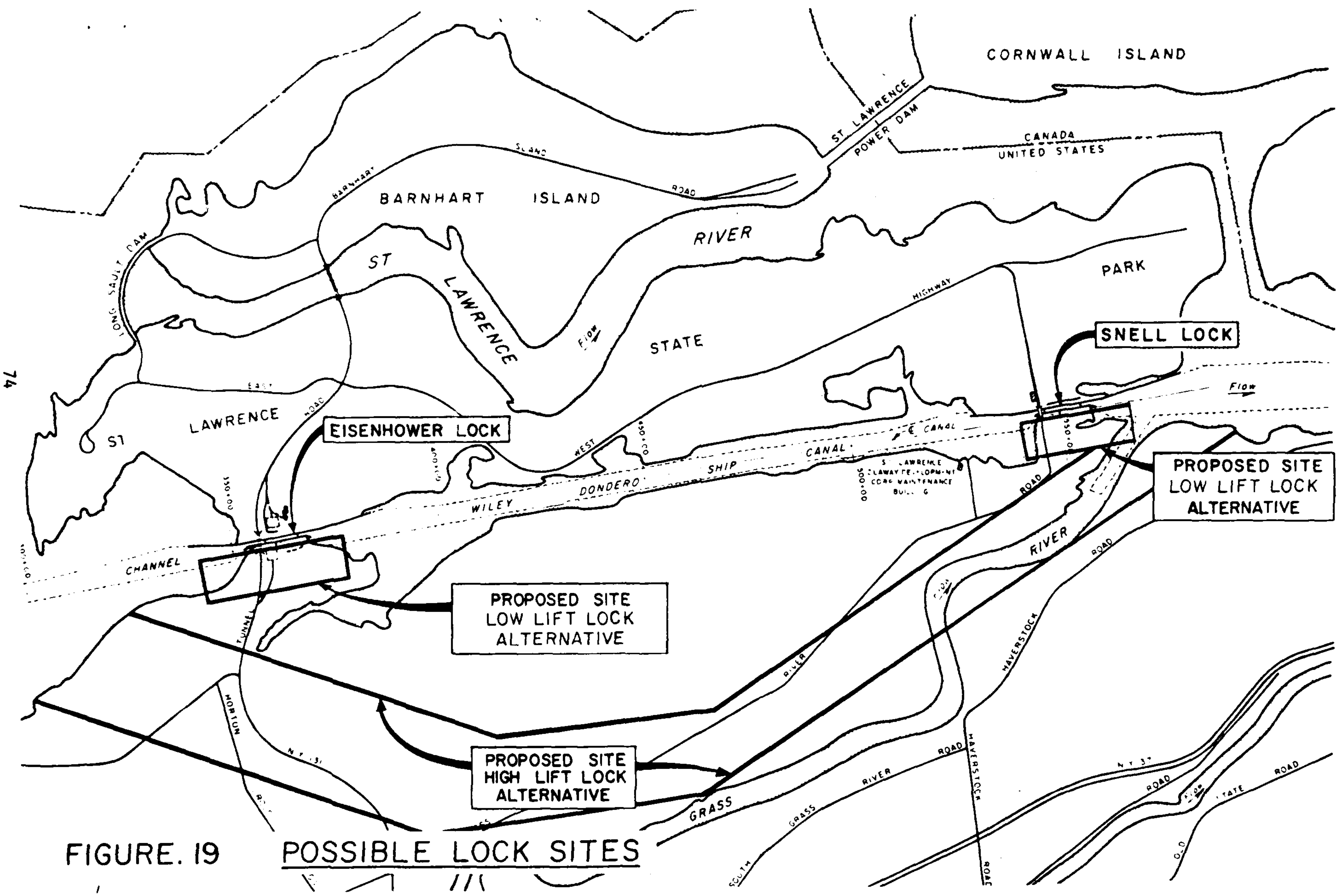



FIGURE. 19 POSSIBLE LOCK SITES

Table 7 - One High-Lift vs. Two Low-Lift Locks

| | Advantages | Disadvantages |
|---|---|---|
| One High-Lift Lock | Reduces the number of locks in the system. | More costly to build (by about $30,000,000). |
| | Potentially less costly to operate. | Dredging associated with this alternate is approximately 10 times the two lock alternate (about 43,000,000 cy). |
| | | Most severe environmental impacts. |
| Two Low-Lift Locks | Less costly to build. | More locks in the system |
| | Required dredging about 1/10th that of high-lift alternate (about 47,700,000 cy). | Potentially high O&M cost. |
| | Least environmentally damaging. | |

Based on the above, the two lower-lift locks are considered somewhat better than the one high-lift lock and were used in assessment. However, only for purposes of capacity modeling, and development of costs, the one high-lift lock was assumed in the analyses for this report. The recommendation as to which possibility should be developed further will be discussed later.

Table 8 - Summary of Plans

| Lock Plan / Channel Depth (feet below LWD) | New Locks to Replace Existing System (1) | | | | Additional New Locks Plus Using Existing System (2) | |
|---|---|---|---|---|---|---|
| | 115 Feet W X 1,200 Feet L Poe-Sized | 115 Feet W X 1,350 Feet L | 145 Feet W X 1,460 Feet L | 115 Feet W X 1,800 Feet L Tandem-Sized | 80 Feet W X 860 Feet L Parallel System of Seaway-Sized Locks | 115 Feet W X 1,200 Feet L Parallel System 2 Seaway-Sized 1 Poe-Sized |
| 27.0 (26.0 Draft)(3) | RX27 | RXI27 | RXII27 | RX27T | AVII27 | AX27 |
| 30.0 (28.0 Draft)(4) | RX30 | RXI30 | RXII30 | RX30T | Not Evaluated | Not Evaluated |
| 32.0 (30.0 Draft)(4) | RX32 | RXI32 | RXII32 | RX32T | Not Evaluated | Not Evaluated |

(1) Existing Seaway locks removed from operation.
(2) Existing Seaway locks kept in operation.
(3) Design draft is 25.5 feet with an authorized seaway operating agency approved draft of 26.0 feet.
(4) Present channel design criteria recommends a 2-foot under keel clearance for any deepening plan.

Based on the features shown in the table above, plans have been given identifying codes. The code based on the first field; R, represents replacement of the existing lock system; A, represents the addition of a parallel system; and D, represents deepening the existing system, respectively.

The second field is a character or group of characters representing the Roman Numeral for the class of the ship size able to use the system.

The third field is composed of two numerals representing the channel depth.

The fourth field, if present, has the character T representing tandem locking capability for Class VII vessels. Example:

RX32T - R - Replacement locks

RX32T - X - Class X

RX32T - 32 - 32-foot draft

RX32T - T - Tandem

## PLANS

The concepts that are viable following the initial screening are further developed in this section. They are developed into specific plans or alternatives for this Preliminary Feasibility Report. These plans/alternatives include new similar sized or larger locks operating as replacements for or additions to (parallel system) the existing locks. In addition, three different system depths are being analyzed. Note that certain plans were developed specifically for alternate futures and not the most probable future. Table 8 outlines the plans in summary fashion. Figure 20 illustrates typical lock plans and comparable vessel sizes included in some plans. Table 9 displays the ship size capacities of the various lock sizes under consideration.

Table 9 - Ship Size Capacities of Various Lock Sizes

| Alternatives | Lock Chamber Size | Maximum Ship Size |
|---|---|---|
| Seaway-Sized, Class VII | 860' X 80' | 730' X 76' |
| Poe-Sized, Class X | 1,200' X 115' | 1,000' X 105' (1) |
| 1,100-Footer, Class XI | 1,350' X 115' | 1,100' X 105' |
| 1,200-Footer, Class XII | 1,460' X 145' | 1,200' X 130' |
| Tandem | | |
| 1 Class X | 1,800' X 115' | 1,100' X 105' |
| 2 Class VII's | 1,800' X 115' | 730' X 76' (2 Ships) |

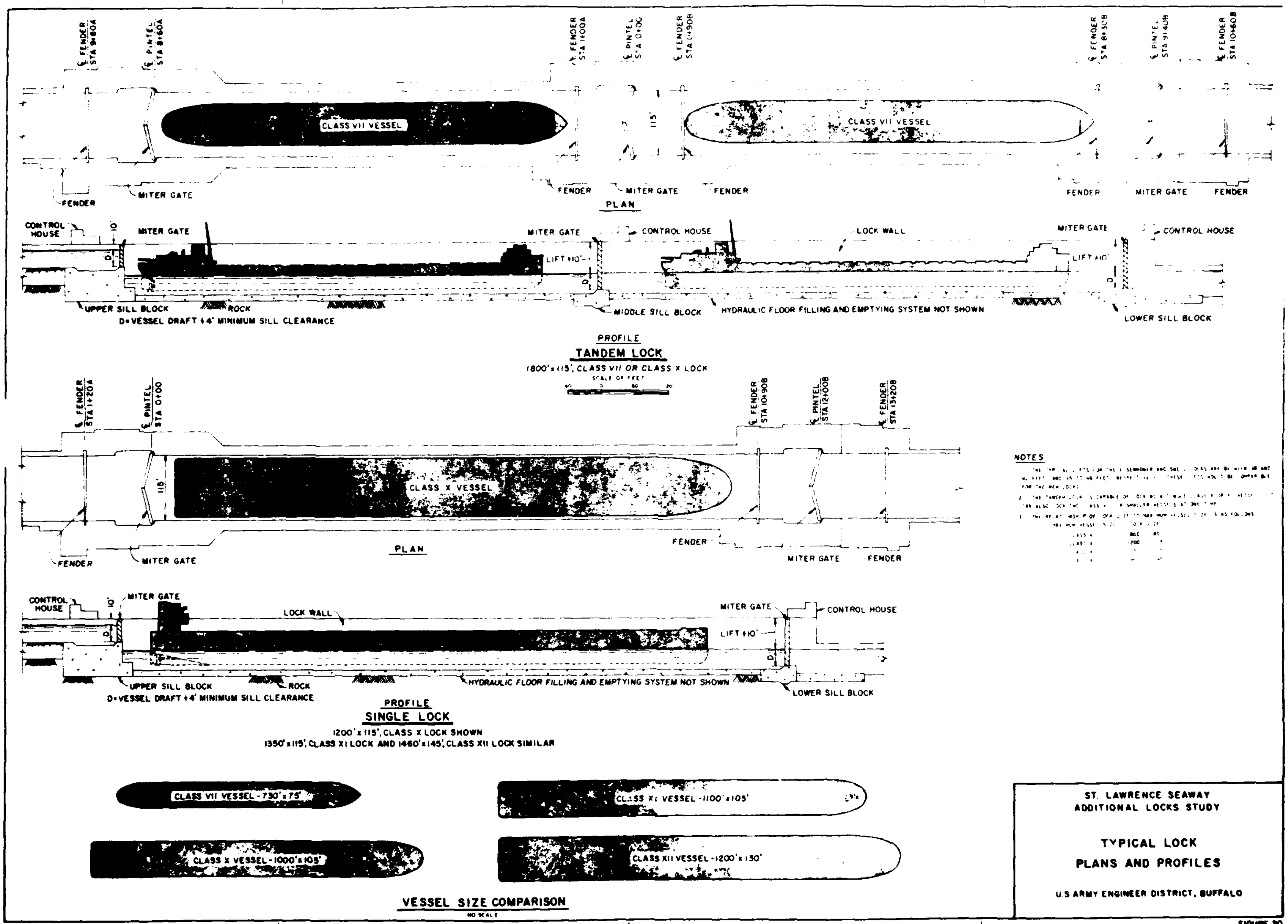
(1) Operating procedures have been modified to allow a maximum ship size of 1,100' X 105' to lock through the current Poe Lock with special handling procedures.

The following alternatives are based on Concept 14. They address the most probable future and alternate future 3 as well. If Concept 12 is incorporated into these alternatives, they are also suitable for alternate future 2.

Alternative RX27 - Build new "Poe-Sized" (chamber size 115 feet wide by 1,200 feet long) locks to replace the existing locks. Channels would require widening for the new maximum ship beam of 105 feet.

Alternative RXI27 - Build new larger locks capable of handling a Class XI ship (chamber size: 115 feet wide by 1,350 feet long). Channels would require widening for the new maximum ship beam of 105 feet.

Alternative RXII27 - Build new larger locks capable of handling a Class XII ship (chamber size: 145 feet wide by 1,460 feet long). Channels would require widening for the new maximum ship beam of 130 feet.



℄ FENDER STA 9+80A
℄ PINTEL STA 8+60A
℄ FENDER STA 1+00A
℄ PINTEL STA 0+00
℄ FENDER STA 0+90B
℄ FENDER STA 8+30B
℄ PINTEL STA 9+40B
℄ FENDER STA 10+60B
CLASS VII VESSEL
CLASS VII VESSEL
115'
FENDER
MITER GATE
FENDER
MITER GATE
FENDER
FENDER
MITER GATE
FENDER
PLAN
CONTROL HOUSE
MITER GATE
MITER GATE
CONTROL HOUSE
LOCK WALL
MITER GATE
CONTROL HOUSE
LIFT +10'
LIFT +10'
UPPER SILL BLOCK
ROCK
MIDDLE SILL BLOCK
HYDRAULIC FLOOR FILLING AND EMPTYING SYSTEM NOT SHOWN
LOWER SILL BLOCK
D=VESSEL DRAFT +4' MINIMUM SILL CLEARANCE
PROFILE
TANDEM LOCK
1800' x 115', CLASS VII OR CLASS X LOCK
SCALE OF FEET
℄ FENDER STA 1+20A
℄ PINTEL STA 0+00
℄ FENDER STA 10+90B
℄ PINTEL STA 12+00B
℄ FENDER STA 13+20B
CLASS X VESSEL
115'
PLAN
FENDER
MITER GATE
FENDER
MITER GATE
FENDER
NOTES
CONTROL HOUSE
MITER GATE
LOCK WALL
MITER GATE
CONTROL HOUSE
LIFT +10'
UPPER SILL BLOCK
ROCK
HYDRAULIC FLOOR FILLING AND EMPTYING SYSTEM NOT SHOWN
LOWER SILL BLOCK
D=VESSEL DRAFT +4' MINIMUM SILL CLEARANCE
PROFILE
SINGLE LOCK
1200' x 115', CLASS X LOCK SHOWN
1350' x 115', CLASS XI LOCK AND 1460' x 145', CLASS XII LOCK SIMILAR
CLASS VII VESSEL - 730' x 75'
CLASS XI VESSEL - 1100' x 105'
CLASS X VESSEL - 1000' x 105'
CLASS XII VESSEL - 1200' x 130'
VESSEL SIZE COMPARISON
NO SCALE
ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
TYPICAL LOCK
PLANS AND PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
FIGURE 20

Alternative RX27T - Build new "tandem" locks capable of handling two ships of Class VII or less or one Class X ship in one lockage (chamber size: 115 feet wide by 1,800 feet long). Channels widening for the new maximum ship beam of 105 feet.

The following alternatives are based on Concept 15, and address the most probable future and alternate future 3 as well. If concept 12 is incorporated into the alternatives, they are suitable for alternate future 2.

Alternative RX30 - Same as RX27 except the existing system channels are dredged 3 feet to a new depth of 30 feet.

Alternative RX32 - Same as RX27 except the existing system channels are dredged 5 feet to a new depth of 32 feet.

Alternative RXI30 - Same as RXI27 except the existing system channels are dredged 3 feet to a new depth of 30 feet.

Alternative RXI32 - Same as RXI27 except the existing system channels are dredged 5 feet to a new depth of 32 feet.

Alternative RXII30 - Same as RXII27 except the existing system channels are dredged 3 feet to a new depth of 30 feet.

Alternative RXII32 - Same as RXII27 except the existing system channels are dredged 5 feet to a new depth of 32 feet.

Alternative RX30T - Same as RX27T except the existing system channels are dredged 3 feet to a new depth of 30 feet.

Alternative RX32T - Same as RX27T except the existing system channels are dredged 5 feet to a new depth of 32 feet.

The following alternative is based on Concept 16 and Concept 11 and addresses alternate future 1 only:

Alternative AVII27 - Use nonstructural plans till capacity then build new "Seaway-sized" (chamber size: 80 feet wide by 860 feet long) locks to complement the existing locks (operate them as a parallel system). No channel deepening or widening would be required.

The following alternative is based on Concept 17 and addresses the most probable future and alternate future 2 as well. If Concept 12 is incorporated into the alternative it is suitable for alternate future 1.

Alternative AX27 - Build a new "Poe-sized" (chamber size: 110 feet wide by 1,200 feet long) lock(s) to complement the existing locks (operate them as a parallel system). Channels would require widening for the new maximum ship beam (105 feet).

The following alternative is based on none of the previously discussed concepts:

Alternative NA - The "no-action" plan assumes that no Federal action would be undertaken in U.S. territorial waters to expand the capacity of the existing Great Lakes/St. Lawrence Seaway (GL/SLS) system. This is the "do nothing" plan which establishes the without project condition. Certain nonstructural measures could be implemented under operating agency authority without Federal action under this study authority. Such measures would help form the most probable future.

OTHER STUDY PLANS

a. Alternate Trade Routes.

(1) Lake Erie-Lake Ontario Waterway (LE-LO) Study

This study, by the Buffalo District, investigated a waterway alternative to the Welland Canal which is the only connection for deep-draft vessels between Lake Erie and Lake Ontario. Based on historical traffic increases and projected increases in traffic volume, the Welland Canal is expected to reach capacity by about 1990. Therefore, the investigation pursued alternate waterways which would provide additional capacity to maintain a growing and efficient waterway system between Lake Erie and Lake Ontario. One of the assumptions of the study was that only routes in U.S. territory would be considered. Figure 21 shows the proposed LE-LO route as well as the Welland Canal. It also shows a proposed location of a new Welland Canal which was developed by the Canadians around the same time as the U.S. proposal to allow for increased traffic between Lake Erie and Lake Ontario. The investigations concluded that the LE-LO Waterway would be hydraulically, geologically, engineeringly and ecologically feasible, but not economically justified, based solely on transportation savings to United States traffic. Further investigations were then curtailed until the later Great Lakes - Hudson River Waterway Study which is described next.

(2) Great Lakes-Hudson River Waterway (Great Lakes to Eastern Seaboard All-American Canal) Survey Study

This study was undertaken to determine the advisability of constructing an All-American transportation system connecting Lake Erie to the Eastern Seaboard with emphasis on development of waterborne commerce and Great Lakes ports. The initial step in this study was to conduct a reconnaissance level study to examine an array of alternative routes and transportation modes that would be capable of transporting the projected increases of various commodities from the Great Lakes Region to the Atlantic Ocean. The alternative transportation plans investigated were deep draft ship canals, deep draft barge canals, and shallow draft barge canals. Four alternative routes were investigated. Figure 22 shows the locations of the routes which are described as follows:

- Route 1 - The Lake Ontario Route - Route 1 primarily follows the Hudson River, the Erie Canal-East, the Oswego Canal, Lake Ontario, and either

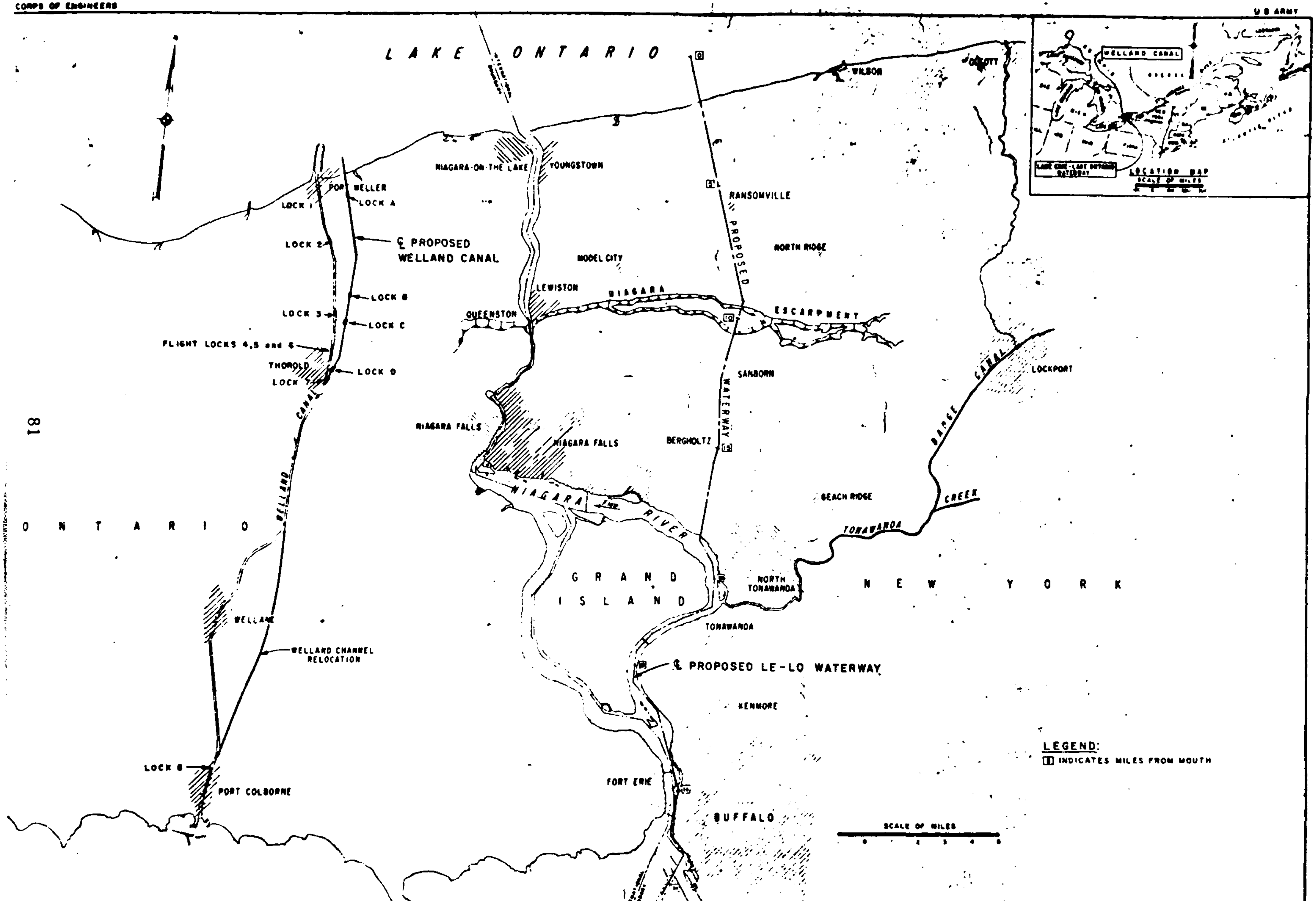



FIGURE 21 LOCATION OF LAKE ERIE-LAKE ONTARIO WATERWAY

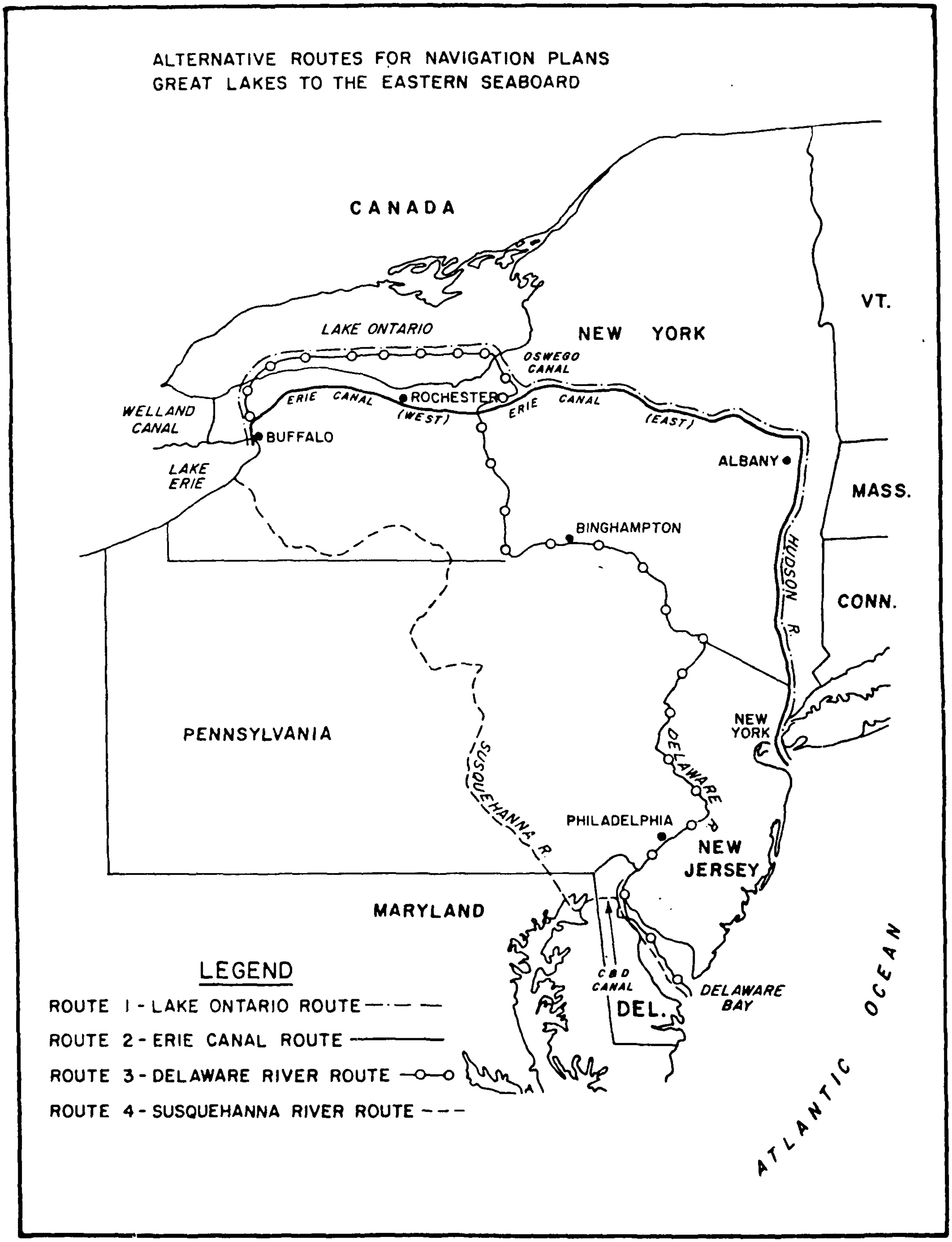

ALTERNATIVE ROUTES FOR NAVIGATION PLANS
GREAT LAKES TO THE EASTERN SEABOARD
CANADA
LAKE ONTARIO
NEW YORK
VT.
OSWEGO CANAL
WELLAND CANAL
ERIE CANAL (WEST)
ROCHESTER
ERIE CANAL (EAST)
BUFFALO
LAKE ERIE
ALBANY
MASS.
BINGHAMPTON
HUDSON R.
CONN.
PENNSYLVANIA
SUSQUEHANNA R.
DELAWARE R.
NEW YORK
PHILADELPHIA
NEW JERSEY
MARYLAND
C&D CANAL
DEL.
DELAWARE BAY
ATLANTIC OCEAN
LEGEND
ROUTE 1 - LAKE ONTARIO ROUTE
ROUTE 2 - ERIE CANAL ROUTE
ROUTE 3 - DELAWARE RIVER ROUTE
ROUTE 4 - SUSQUEHANNA RIVER ROUTE

FIGURE NO. 22

the course of the Lake Erie-Lake Ontario (LE-LO) connecting waterway or the existing Welland Canal. Deep draft navigation plans would use the proposed LE-LO Waterway, whereas shallow draft navigation plans would make use of the existing Welland Canal facility.

- Route 2 - The Erie Canal Route. Route 2 follows the Hudson River, the entire Erie Canal, and the Niagara River via the Black Rock Canal from New York City Harbor to Lake Erie at Buffalo.

- Route 3 - The Delaware River Route. Route 3 begins at the Delaware Bay and follows the Delaware River, the Upper Susquehanna River, Lake Cayuga and a small reach of the Erie Canal to Three Rivers Junction. From this point, Route 3 follows the Oswego Canal, Lake Ontario, the LELO Canal, and the Niagara River via the Black Rock Canal to Lake Erie at Buffalo.

- Route 4 - The Susquehanna River Route. Route 4 follows the Delaware Bay, the Chesapeake and Delaware (C&D) Canal to the Chesapeake Bay, the Susquehanna River, and a number of small rivers west to Lake Erie at Silver Creek, NY.

All of the 13 plans that are described below follow one of these routes:

- Plans 1-6 provide for the rehabilitation or modernization of existing shallow draft barge canals. A shallow draft barge system would permit the passage of barges which draw no more than 13 feet. All of these plans use principally either Routes 1 or 2.

(1) Plans 1 and 2 would provide generally for the rehabilitation of existing locks, guidewalls, dams, spillways, and gated structures in the New York State Barge Canal system. The plan would allow only one barge tow to pass through the canal's locks. Plan 1 would utilize Route 2 as described above; Plan 2 would utilize Route 1. Horizontal and vertical bridge clearances would remain as is and minimal channel work would be required.

(2) Plans 3 and 4 would provide for a modernized, enlarged canal with a 14-foot depth, a 200-foot width in river sections, and 150-foot width in currently canalized sections of the river. Besides the rehabilitation proposed for Plans 1 and 2, the existing locks would be extended or replaced so that two barge tows could be accommodated in a single lockage. Moderate amounts of channel work would be required. Existing guidewalls, dams, spillways, and gated structures would also be rehabilitated. Plan 3 would utilize Route 2; Plan 4 utilizes Route 1.

(3) Plans 5 and 6 would provide a 14-foot depth and 300-foot width throughout the system. Horizontal bridge clearances of 300 feet and vertical bridge clearances of 20 feet would be established. Lock sizes would be increased to allow for single lockages of up to four barge tows, and extensive channel widening would be required. Dams, spillways, and gated structures would be rehabilitated as required. Plan 5 would use Route 2; Plan 6 utilizes Route 1.

• Plans 7 and 8 provide for the construction of a deep draft barge canal system, which would accommodate barges of much greater size than a shallow draft system. The plan would provide for an enlarged canal capable of accommodating barges or tows of not more than 525 feet in length, 105 feet in width, and drawing approximately 27 feet of water. The system would have a channel depth of 30 feet and a straight channel width of approximately 300 feet, which would entail tremendous excavation and dredging activities. Locks would have a width of 110 feet and a usable length of 700 feet. Plan 7 would use Route 2; Plan 8 utilizes Route 1.

• Plans 9, 10, 11, and 12 provide for the construction of deep draft ship canals. These canals would accommodate a ship of about 730 feet in length, 75 feet wide, and drawing approximately 31 feet of water. The system would have a channel depth of 35 feet and a straight channel width of 210 feet and would entail tremendous excavation and dredging activities. Locks would have a width of 80 feet and a usable length of 800 feet. Plan 9 would use Route 2, Plan 10 utilizes Route 1, Plan 11 utilizes Route 3, and Plan 12 uses Route 4.

• Plan 13 provides for the construction of the Lake Erie - Lake Ontario (LELO) Canal only. This is an overland, deep draft ship or barge canal from Lake Ontario south to North Tonawanda, NY, and continuing along the Niagara River via the Black Rock Canal to Lake Erie at Buffalo, NY.

Plans 7 through 13 constitute the deep draft navigation alternatives which could provide an alternative trade route to the St. Lawrence Seaway. Order of magnitude costs and benefits were developed for this preliminary reconnaissance level study to determine which plans warranted further study. Table 10 presents a summary of the costs, benefits, and benefit/cost ratios for all of the deep draft plans.

From observation of the benefit/cost ratios, it is clear that no plan is economically feasible. Because of these figures and the additional unresolved issues of environmental impacts, social well-being, etc., these alternative transportation routes will not be considered as an alternate transportation route to the St. Lawrence Seaway.

b. Transshipment.

It is possible to move bulk commodities relatively short distances around physical constraints by transshipping them via a pipeline, conveyor, barge shuttle service or whatever. Some commodities would lend themselves to such movements, and some would not.

In the case of the lower portion to the GL/SLS system, transshipment, although possible, does not appear to be practical or economical. The only high-tonnage commodity moving on the system is coal, and this movement is primarily downbound through the Welland Canal. In order to move coal via slurry pipeline the following facility needs would be typical: slurry systems upstream, pumping facilities, a pipeline (about 26 miles long), dewatering facilities downstream, and additional loading and unloading system at either end of the Welland Canal.

The costs of such facilities would be very high and probably not be economically feasible. There are also a number of unanswered environmental questions that have not been addressed to determine if such a system would be environmentally feasible. Even if these facilities were constructed and utilized at the Welland Canal, they would only delay the capacity date about 10 to 15 years. At that point, another capacity expansion decision must be made.

From this discussion, it is clear that that transshipment is not the answer to the capacity problem at the Welland Canal or the St. Lawrence River locks.

Table 10 - Great Lakes to Eastern Seaboard (All-American Canal) Study
Economic Summary of Alternative Deep Draft Navigation Plans (1)

| Plan No. | Waterway Reaches Physically Improved or Utilized | First Cost (2) ($ Million) | Annualized First Cost (2) ($ Million) | Range of Estimated Annual Benefits (3) ($ Million) | Range of Benefit/Cost Ratios |
|---|---|---|---|---|---|
| 7 | Erie East and West and Black Rock Canals | 37,325.0 | 2,747.4 | 126.1 - 142.1 | 0.04 - 0.05 |
| 8 | Erie East, Oswego, and LE-LO Canals (Deep Draft Barges) | 27,626.0 | 2,033.5 | 223.3 - 240.2 | 0.11 - 0.12 |
| 9 | Erie East and West and Black Rock Canals (Deep Draft Ships) | 36,150.0 | 2,660.9 | 192.6 - 202.2 | 0.07 - 0.08 |
| 10 | Erie East, Oswego and LE-LO Canals (Deep Draft Ships) | 27,139.0 | 1,997.6 | 276.7 - 284.2 | 0.13 - 0.14 |
| 11 | Delaware River Route (Deep Draft Ships) | 52,950.0 | 3,897.5 | 111.3 - 119.9 | 0.02 - 0.03 |
| 12 | Susquehanna River Route (Deep Draft Ships) | 54,040.0 | 3,977.7 | 152.3 - 181.4 | 0.03 - 0.05 |
| 13 | LE-LO Canal Only (Deep Draft Ships) | 4,231.0 | 311.4 | 74.3 | 0.24 |

(1) Information developed by New York District.

(2) First Cost and annualized cost estimates represent realistic lower bound figures.

(3) Estimated annual benefits represent an upper bound on range of transportation cost savings.

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## IMPACT ASSESSMENT AND EVALUATION

The selection of candidate plans is accomplished through the completion of two primary planning tasks. Those tasks are "Impact Assessment" and "Evaluation." The tasks are initially carried out on all alternatives which address one or more of the planning objectives. The process is repeated several times getting more detailed as the number of iterations increases. The process continues until a reasonable number of candidate plans remain for further consideration. The results of the iterative process also assists with determination of the type and extent of further studies needed to aid in the continuance of the selection process. This section will present the results of the interative process of impact assessment and evaluation.

### IMPACT ASSESSMENT

Impact assessment is the identification, description, and, if possible, measurement of the effects of the different alternative plans on the base year condition. Primary consideration is given to effects which are likely to have a material bearing on the decision making process. Plans are assessed for their technical feasibility and their possible economic, environmental and socioeconomic, and institutional impacts. The aspects of each plan that could cause significant impacts are identified and specified, when possible, according to where, when, magnitude and duration. This determination requires analyzing and displaying monetary and nonmonetary changes in an objective manner based on professional and technical assessment of the resources. The absence of change or no net change from the base condition could also be a significant impact in certain instances, and care is taken to surface such information during this task. Describing impacts does not reflect societal preferences; these preferences are determined through subsequent evaluation.

The following is a discussion of major effects grouped by categories, evaluated during this process. Other effects are included as required by the particular alternatives being assessed. Later, a presentation of the assessment of each plan is presented. Additional information on the regional economic impacts and the impacts on recreational boating are generally discussed after the individual plan impact assessments, because these studies were not performed in a plan specific manner.

a. Technical.

First of all, the capability of the plan to expand the capacity (in terms of tons moved) of the system is analyzed and assessed using a capacity model based on queuing theory. (Queue is a ship waiting to be processed through a lock.) This capability is a function of the lock size, system draft, fleet mix, tonnage per vessel transit, length of season, lock processing time, and availability of the locks for processing. Normally, there is a lock (or locks) in a system which, because of its individual characteristics, is the slowest to process vessels. This lock is termed the "constraining" lock at that particular lock node. The capacity of a particular lock can be measured in terms of the percent of time the lock is being utilized, the tonnage per vessel lockage, the queue length waiting to be processed, or the delay time a

vessel in the queue must wait to be processed. Because each lock is somewhat unique in its ability to process vessels, there is no single definition of "capacity." The analysis done for this report utilized a range of percent lock utilizations to define capacity. The percentages used were 80 and 90 percent. The capacity model used for this analysis of plans allowed for these percentages to be input variables, with the vessel queue length and vessel delay times as output. The model also allowed for use of different traffic forecasts. In this study the ability of the plan to pass two forecasted traffic movements was made, a high and a low forecast. Those forecasts are explained previously in the most probable future section. By utilizing a range of future movements, the stability of a plan under different conditions could be tested.

The output of the capacity model (discussed in detail in Appendix B - Economics) determined the following information which is critical to the assessment and later evaluation of plans: the plan's productivity (its ability to extend capacity in terms of years); the tonnage moving each year up to the plan's capacity, the number of transits required each year up to the plan's capacity; the composite ship class moving the tonnage each year up to the plan's capacity; and the average delays (in hours) encountered each year up to the plan's capacity.

It should also be noted that the capacity model used to analyze these plans was not originally set up to handle the tandem lockage (Plan RX27T) or the parallel operation of locks (Plans AVII27 and AX27). Therefore, the analysis of these three plans, and the results obtained are not to be compared at an equal level of certainty with the analysis for other plans of improvement.

b. Economic.

The costs of each plan are determined for assessment and later evaluation. The cost estimates for each plan are developed from data in the 1977 Maximum Ship Size Study, the Arctec Inc. update of that Study's costs, and additional information obtained from SLSDC and SLSA reports. Detailed cost estimates are in Appendix D - Design and Costs. The major plan costs are for locks, channels, bridges and tunnels, and harbor improvements. Other items include: aids to navigation, real estate, contingency, engineering and design, supervision and administration, non-Federal first costs, and interest during construction.

Each plan was also assessed for benefits and later a comparison of benefits to costs was made. Appendix B - Economics details the benefit derivation. It was prepared by the Buffalo District, utilizing the capacity and benefits models prepared under contract by Booz-Allen and Hamilton, Inc. and Arctec, Inc., and utilizing the guidance and assistance of the North Central Division, Corps of Engineers.

c. Environmental and Socioeconomic Assessment.

The environmental impact assessment and evaluation process primarily used local construction impacts - site specific dredging, changes in amount of vessel traffic, and changes in capacity to determine potential impacts.

The impact analysis, as pointed out, is construction site-specific, and does not attempt to identify or assess cummulative project impacts on the river ecosystem. The NYSDEC has indicated that they are opposed to any project recommendations based upon site-specific data only. They feel ecosystem studies are required prior to completion of feasibility studies. Due to the large cost of the proposed ecosystem studies (about $16 million - see Appendix A for a detailed list of studies), the Corps cannot recommend conducting them until some type of joint study with Canada takes place after the U. S. interest has been determined.

During impact analysis it became evident that the data to predict physical changes, if any, between larger and smaller class vessels was not currently available during preparation of this assessment, so was therefore not used in impact analysis during this phase of the planning effort.

An item considered to have significant impact was dredging which includes deepening and widening of the navigation channel. Figures 23 through 28 show the areas where because of physical conditions, dredging in general is likely to occur; although specific amounts and location do vary according to the specific plan.

The potential environmental and socioeconomic impacts of each plan are developed in detail in Appendix A - Environmental. This appendix was prepared by the Buffalo District using field studies and planning aid letters provided by the U.S. Fish and Wildlife Service, Cortland, NY, field observations by the Buffalo District staff, regional impact and recreation boating impact studies performed by Contractors, and other sources of information.

d. Institutional.

An institutional assessment was made to determine by whom and how any plan would be implemented.

Each plan is described and assessed according to the technical, economic, environmental and socioeconomic, and institutional categories mentioned above with the results of those assessments presented in the next several pages. There are two possible institutional areas which could theoretically be associated with any plan in this report. However, they are not within the traditional realm of Corps studies for water resources projects and not covered for each plan. Two such areas are discussed briefly in the following paragraphs.

(1) National Defense - The St. Lawrence Seaway is a significant transportation resource for the "industrial heartland" of the United States. A significant portion of the heartland's raw materials, agricultural products, and finished manufactured goods move via the Seaway. In times of national emergency, this resource becomes even more important. A larger Seaway system could presumably move more of the vital materials which would aid in the strengthening the U.S. strategic position at such a crucial time. Naturally, because the Seaway system includes Canadian locks, agreements with the Canadians would be required.

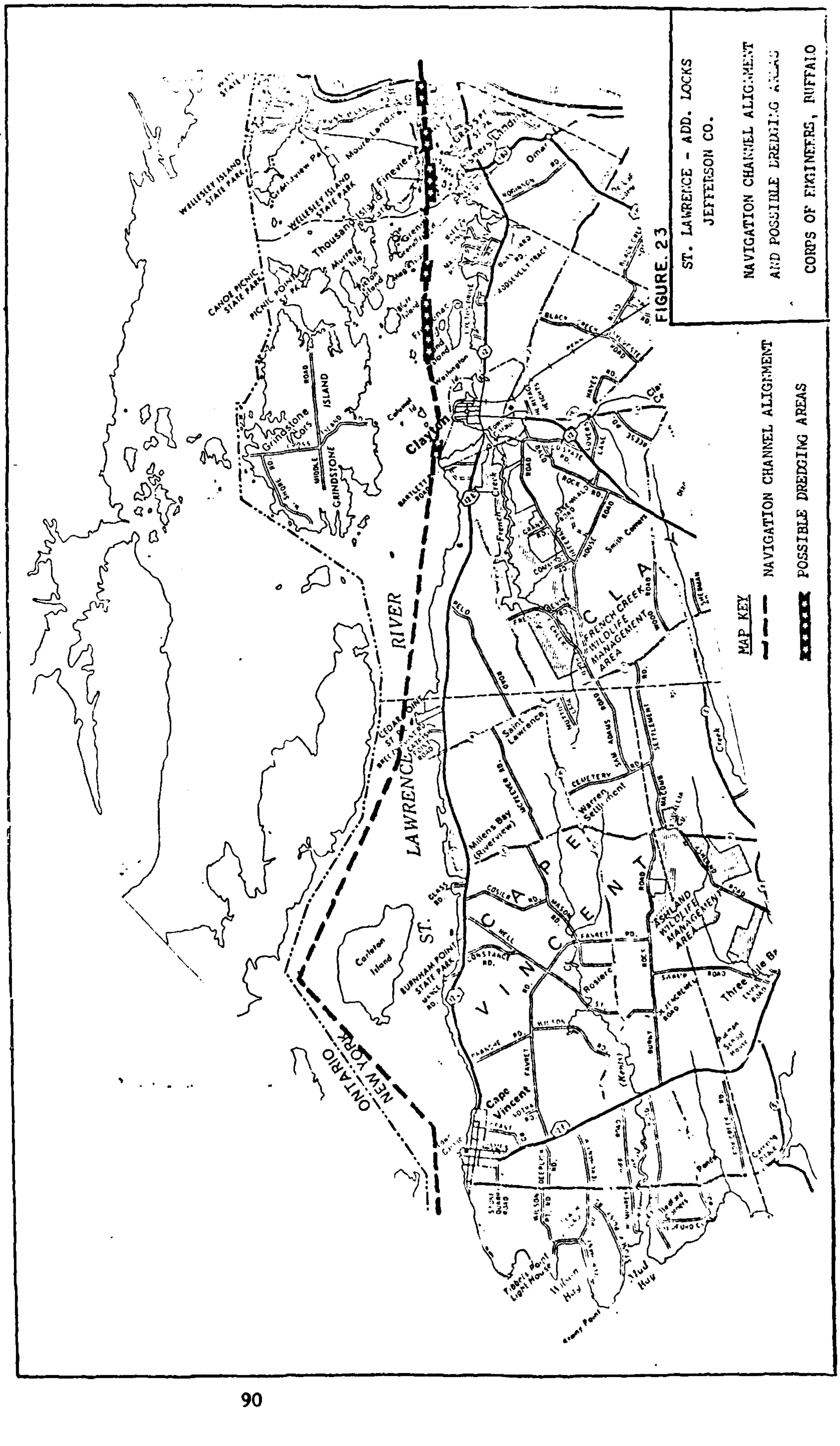



FIGURE. 23

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

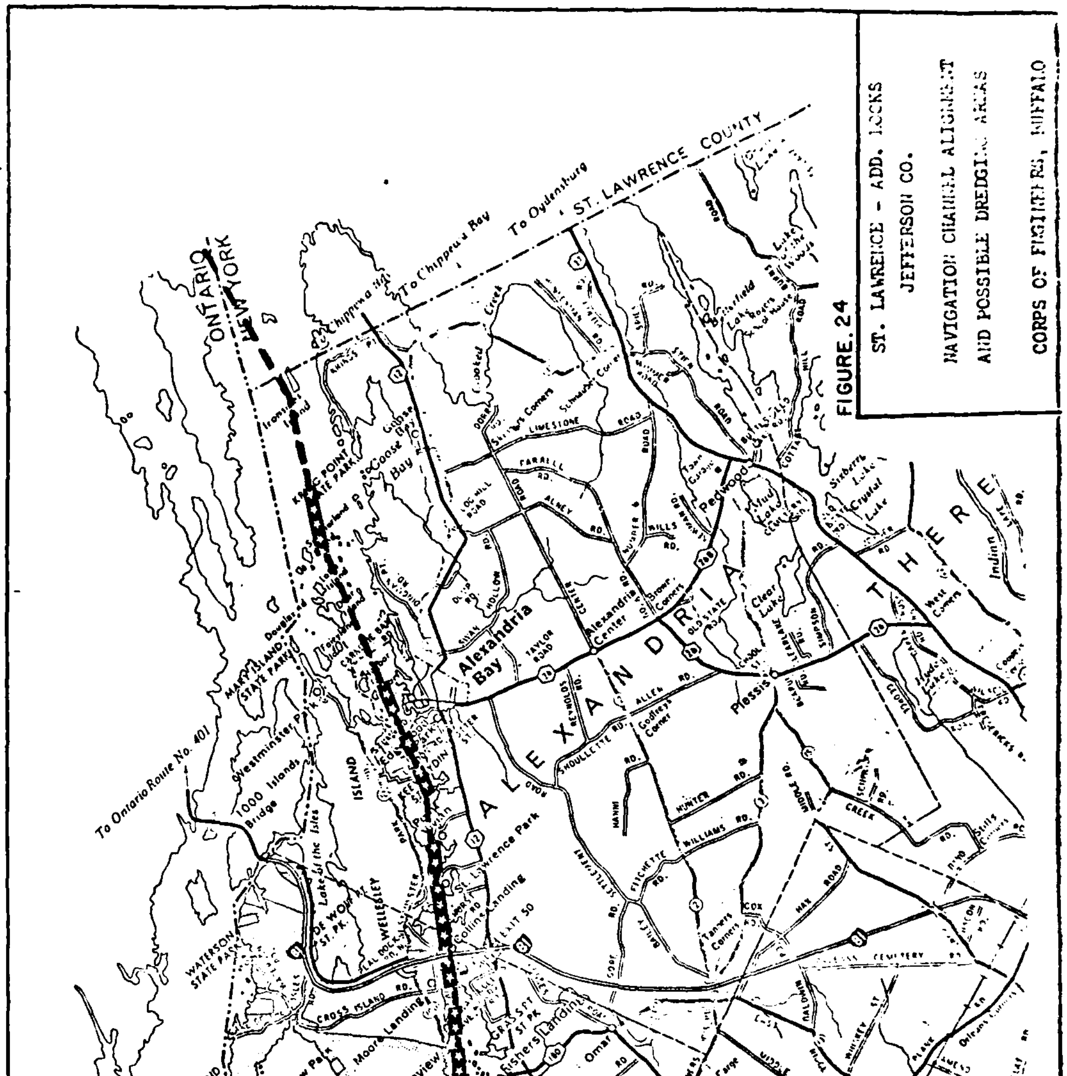



FIGURE. 24

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS
CORPS OF ENGINEERS, BUFFALO

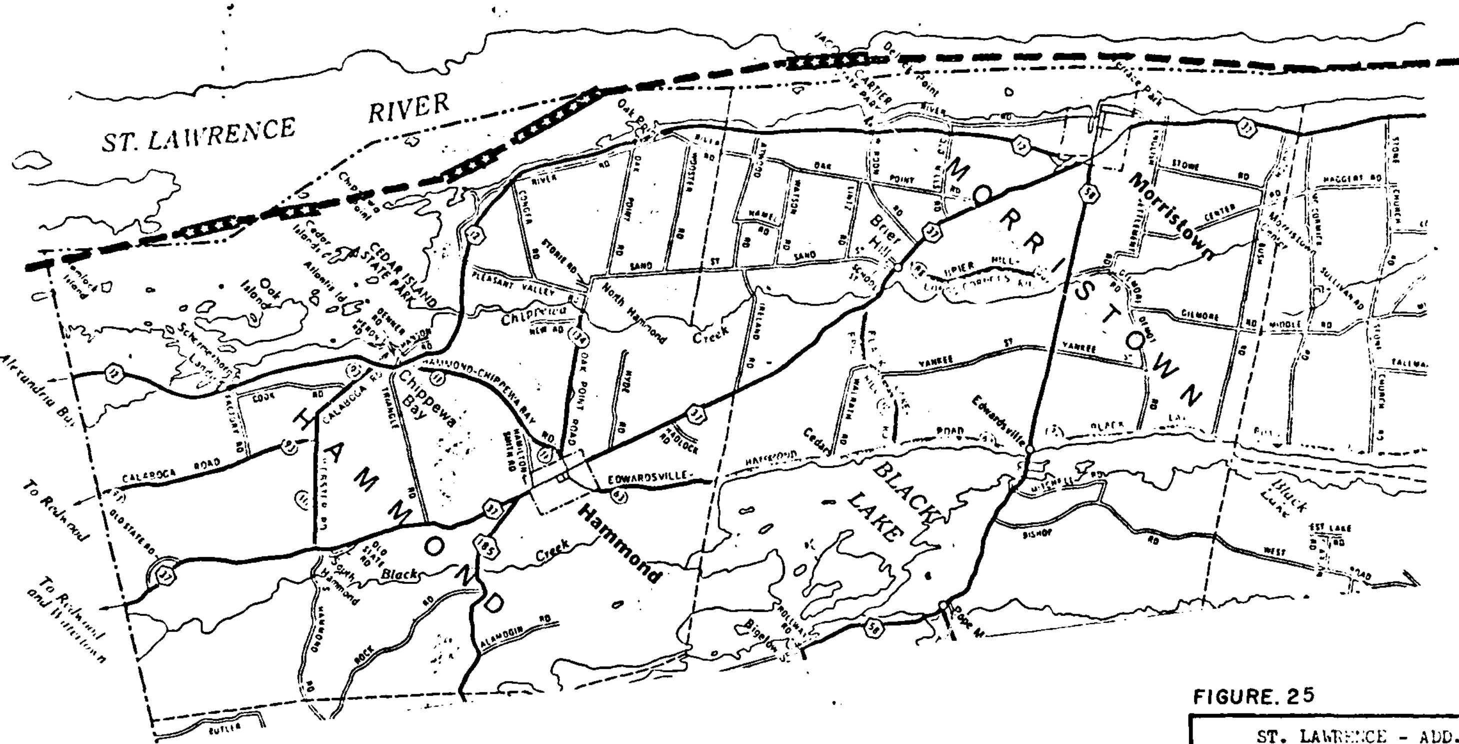



FIGURE. 25

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

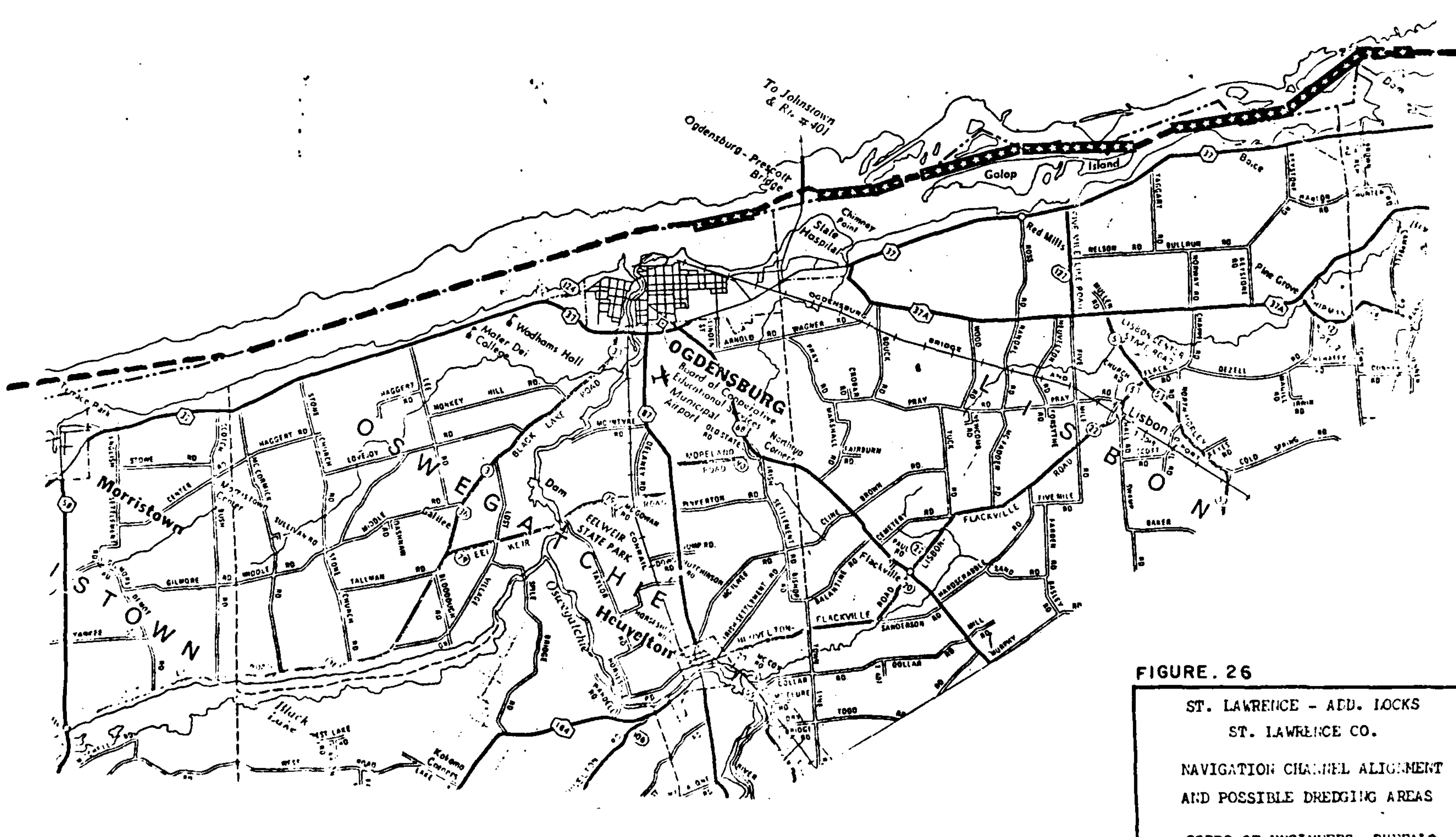



FIGURE. 26

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

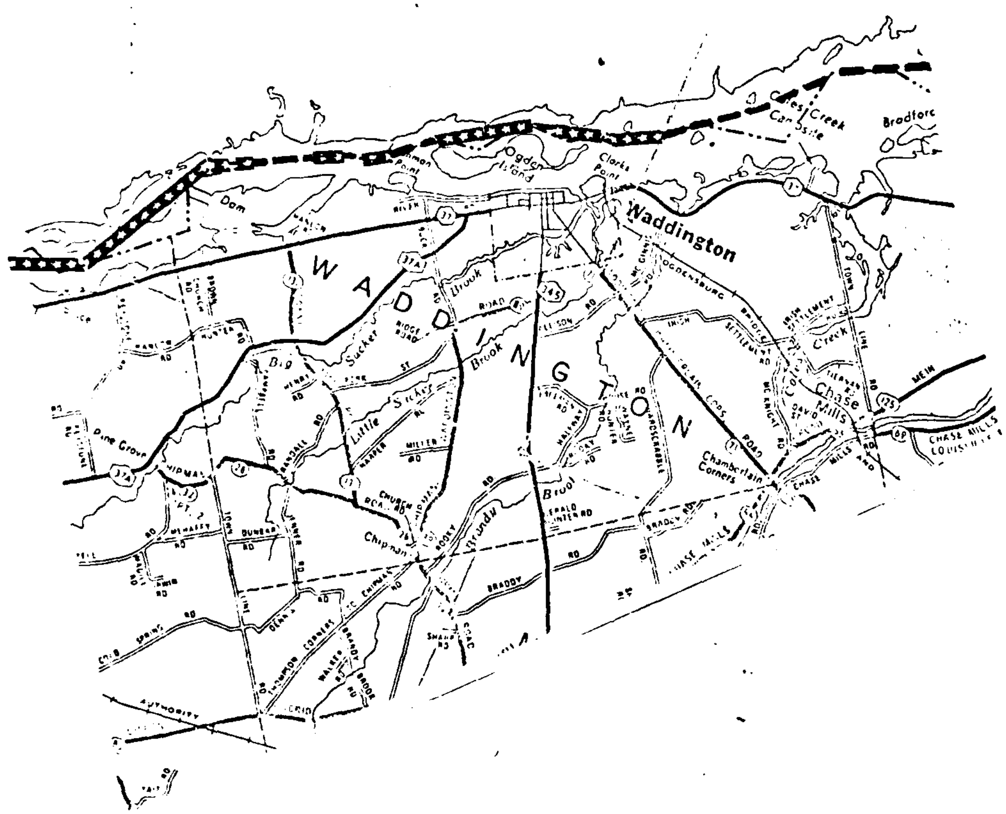



FIGURE. 27

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

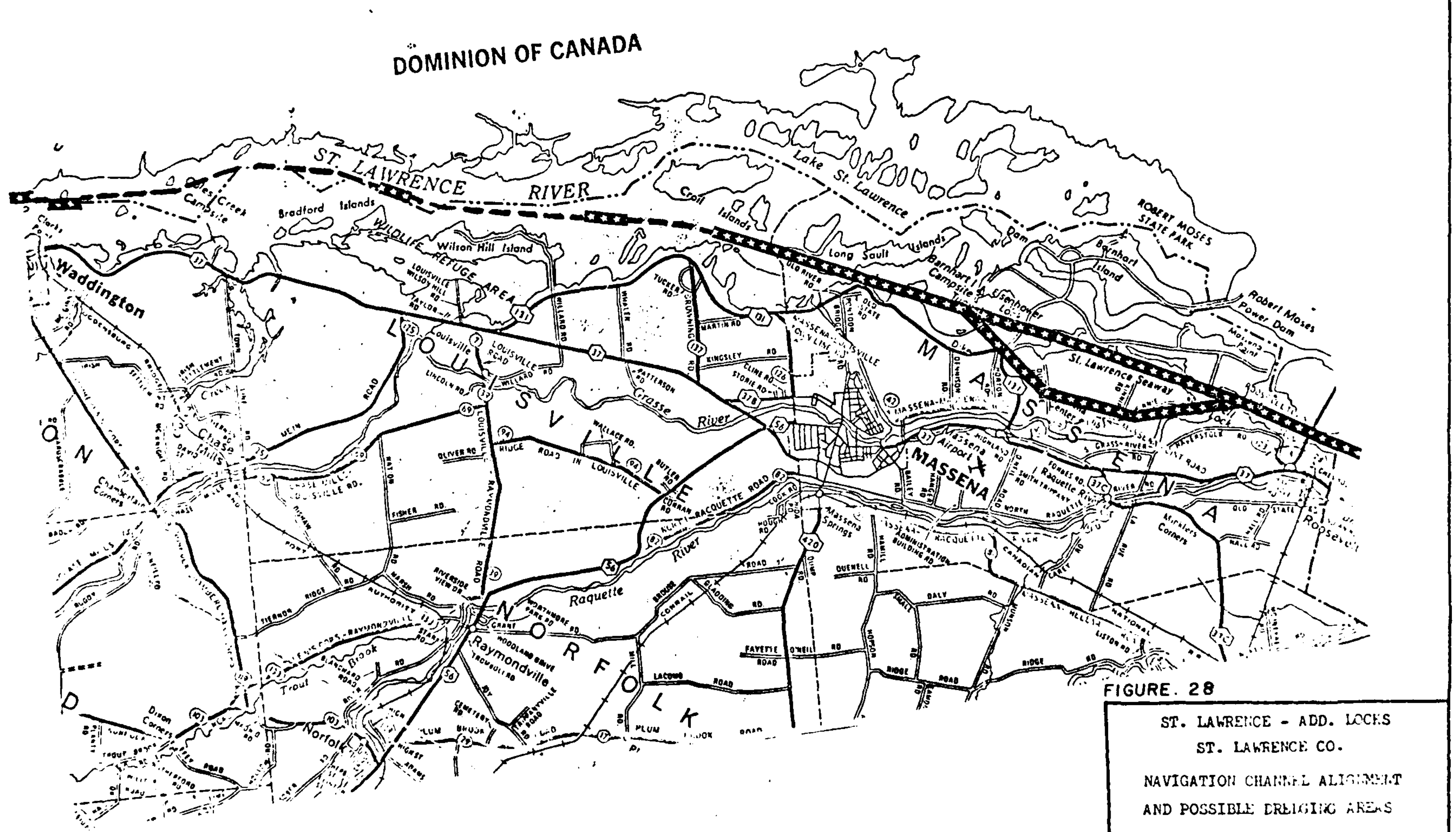



FIGURE. 28

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

The existing system was not in place during World War II or the Korean War, so that past experience in times of national emergency cannot be used as an example. Presumably, if east coast ports were not able to handle the induced increase in movements, or if they were blockaded, the Seaway could provide a backup system to move the necessary commodities. This may be an important consideration in any future political decision to be made on improvement of the Seaway.

(2) Maintaining U.S. Interests - At the present time, the U.S. operates and maintains two of the seven locks in the St. Lawrence River. This level of project ownership is significant enough to warrant representation in all International negotiations and decision making for the waterway. That is, by being involved in the project, the U.S. has a say in the regulation of the waterway, establishment of tolls, and dispersement of revenues.

Without a significant portion of the investment in any future improvement project, the U.S. could not expect to have the same level of involvement in the proposed project. This could possibly jeopardize the future bargaining position of the U.S. in any matters involving the St. Lawrence Seaway. A political decision will be required to determine whether or not this potential situation is significant enough to warrant continued U.S. involvement.

These two aforementioned institutional areas, along with the other analyses presented in this report will undoubtedly all be considered in determining the U.S. interest in any future project of this type.

e. Plan DVII30.

(1) Description and Technical Assessment - This plan requires that the existing channels in the U.S. portion of the St. Lawrence River be deepened from the existing depth of 27.0 feet below LWD to a minimum depth of 30.0 feet (31.0 feet in rock) below LWD. Plan implementation would require modifications to existing locks, and would require systemwide deepening (i.e., Canadian channels in the St. Lawrence River and Welland Canal, and the connecting channels and harbors in the upper four Great Lakes) for compatibility.

Note that this plan was found technically unsound during the initial screening process in the plan formulation section because the existing lock sills at the St. Lawrence River and Welland Canal locks are not designed for ships operating at 28.0 feet below LWD, a draft which would be available in the channels if the plan were implemented. This plan was described and run through the lock capacity model only to determine how long it would delay capacity, for comparison with the other plans being developed. The following table shows plan productivity at the constraining lock node (i.e., the Welland Canal).

Table 11 - Productivity of Plan DVII30

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | NE | 16 Years (1994-2010) |
| High | NE | NE |

NE - Not evaluated for this condition.

(2) Economic Assessment - None was performed because plan is technically unsound.

(3) Environmental and Socioeconomic Assessment - This plan would have a significant environmental impact because it requires dredging and disposal of approximately 5.4 million cubic yards of material in order to deepen portions of the river 3 feet (from 27.0 feet to 30.0 feet).

(4) Institutional Assessment - None performed.

f. Plan RX27.

(1) Description and Technical Assessment - This plan consists of construction of new "Poe-sized" locks to replace the current Eisenhower and Snell locks with no channel deepening. Lock chamber dimensions for this plan will be 1,200 feet long by 115 feet wide, with lock gate sills at 30.0 feet below LWD (considered sufficient for 25.5-foot draft). This plan would accommodate a 1,000-foot vessel. The total lift of both locks will be between 83 and 91 feet (depending on conditions up and downstream from the locks). A new navigation channel will not have to be prepared for these locks but entrance and exit channel work will be necesary. Figure 29 shows the approximate location. (The location of locks given for this plan and other plans that follow are only proposed sites. Other sites may be feasible and will be evaluated in later studies. For this study only, the low lift locks are considered.) A new tunnel will also be required under the navigation channel to maintain traffic between Massena, NY, and Cornwall, Ontario. This plan carries the projected traffic for the low forecast and approaches the 50-year goal. It is not suitable for high traffic forecast because of the short productivity. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identfies when a change would be required for the St. Lawrence Seaway System to be compatible with the Welland Canal and how long until system capacity is again reached.

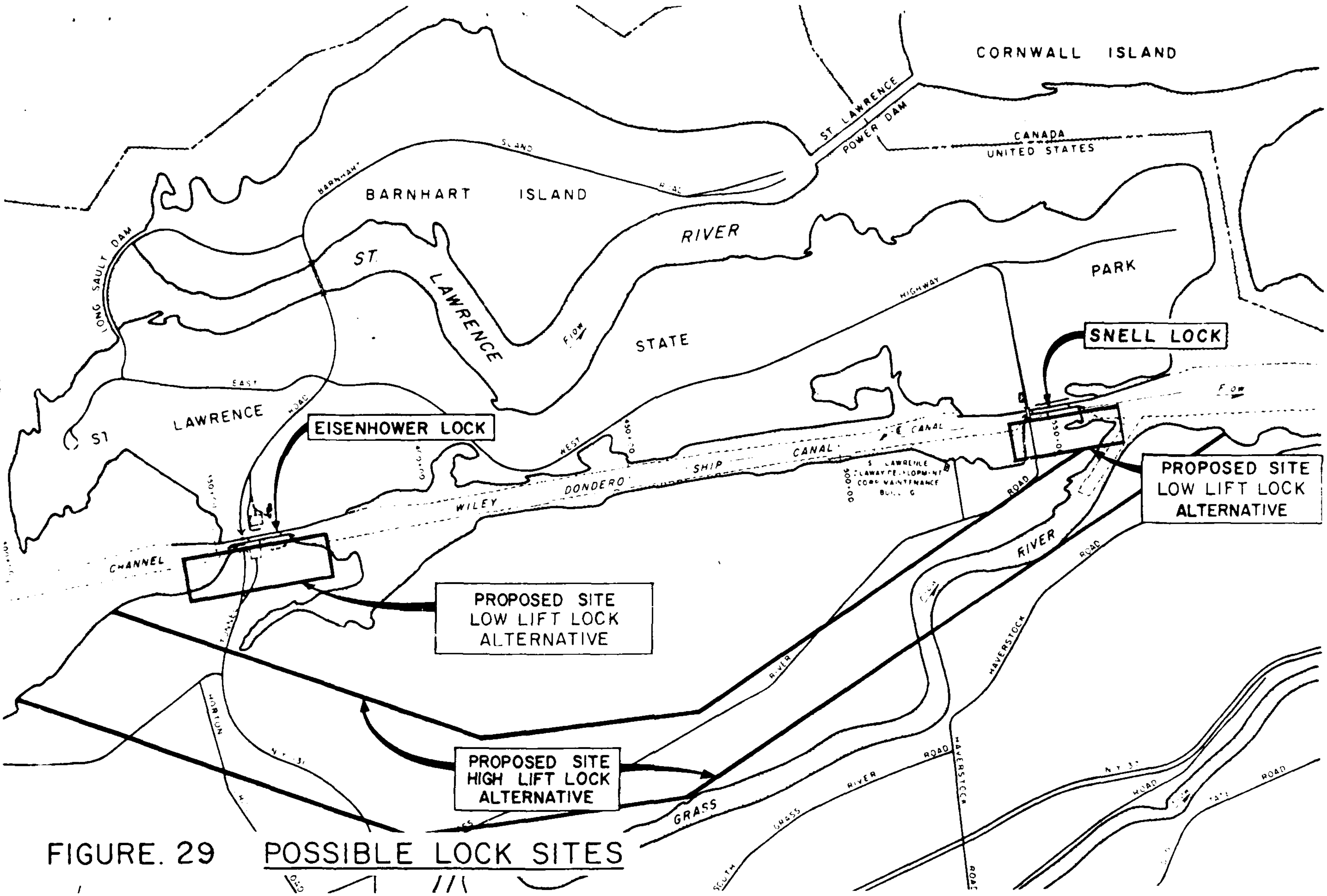



FIGURE. 29 POSSIBLE LOCK SITES

Table 12 - Productivity of Plan RX27

| Traffic Forecast | Percent Lock Utilization: 80 Percent | 90 Percent |
|---|---|---|
| Low | 47 Years (1985-2032) | 44 Years (1994-2038) |
| High | 12 Years (1982-1994) | 14 Years (1984-1998) |

This plan meets all critical technical criteria.

(2) Economic Assessment - The capital construction cost for this plan and those that follow is based on costs for: dredging, two new locks (the cost of one high-lift lock and two lower-lift locks was considered to be relatively the same, see Appendix D), a new tunnel, 20 percent of system harbor improvement costs, aids to navigation, real estate, and contingencies.

Engineering and design, supervision and administration, non-Federal first cost, and interest during construction were also added in. The detailed cost estimates are found in Appendix D. The total investment cost for Plan RX27 is estimated to be $1,040,000,000. This equates to an average annual cost of $81,400,000.

The potential benefits from this plan are divided into three categories: transportation rate savings, vessel utilization savings, and vessel delay savings. The detailed discussion of these categories, methodology for their development, and their calculations are presented in Appendix B - Economics. Table 13 shows the average annual benefit for each category, the total average annual benefit, the net average annual benefit, and the benefit/cost ratio for this plan. This plan meets all critical economic criteria.

Table 13 - Summary of Benefits and Costs for Plan RX27
Numbers are in Millions of Dollars

| Low Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 23.8 | 76.0 | 16.8 | 116.6 | 81.4 | 35.2 | 1.43 |
| 90 Percent Util. | 27.6 | 59.2 | 32.9 | 119.7 | 81.4 | 38.3 | 1.47 |

(3) Environmental and Socioeconomic Assessment - This plan will require approximately 40 acres of land for construction of locks and connecting channels. This however, is generally open field and primarily owned by the St. Lawrence Seaway Development Corporation. No displacement of people or significant impact to land use plans is anticipated. Construction of two new "Poe-sized" locks in the Massena area would require the excavation of approximately 4.7 million cubic yards of terrestrial material. This excavation would primarily destroy open areas, but some shrublands, deciduous and coniferous forests, and some small cattail marshes would also be destroyed. Such construction activity would disturb and probably displace existing small mammals, birds, amphibians and reptiles from the project zone. Once construction is completed, wildlife would be expected to return on graded or landscaped areas to some degree, but there would be an overall loss of field habitat.

The plan would require dredging to widen the channel and disposal of approximately 8.3 million cubic yards of channel material from the St. Lawrence River to safely accommodate the new larger vessel beam. This would require some dredging in the new lock areas and at various points along the river (see Figures 23 through 28). Dredging would be expected to cause localized short-term deteriorization of water quality due to increased sedimentation and cause localized destruction of existing benthos, however, populations should soon reestablish from upriver and adjacent benthic populations. The fishery of the area would be temporarily displaced from the construction zone, and could be impacted significantly if important spawning, nursery or feeding areas were destroyed by dredging.

Long-term effects - pertaining to the area fisheries, wildlife, ecology, aesthetics and recreational environment - although not expected to be significant at this time, are difficult to assess with only existing available information, and must be examined in more detail in development of the Draft EIS.

This alternative would increase the Seaway system capabilities and capacities; and, would fully conform to existing and anticipated future Canadian and Upper Lakes systems. Generally, significantly more tonnage could be efficiently transported in fewer transits. Assuming similar system-wide improvement capabilities, preliminary studies indicate that significant Great Lakes regional benefits could be realized. Increased capacity would facilitate waterborne commercial, industrial, and agricultural transportation needs through increased capacity for shipment of anticipated increased commodities and through rate savings resulting from continued use of the system, instead of cargo being forced to use a more expensive route and mode. Some associated employment and income, and community developmental benefits might also be expected which would help to stabilize and/or promote continued community and regional socioeconomic growth.

Although structural plans involving significant construction and dredging significantly increase system capacities, they also have greater potential for immediate adverse impacts to the environment and impact susceptible local vicinities - primarily the connecting lock and channel areas and some harbor areas. Some induced modifications to regional harbor facilities might also

be expected. Benefits must be weighed against costs and potential overall environmental adverse impacts and effects.

Few benefits would be realized by the people or communities along the U.S. portion of the St. Lawrence River as a result of any system improvements. Ogdensburg Harbor is the only U.S. commercial harbor along this section of the river and would not benefit significantly from Seaway improvement measures. The remaining U.S. communities along this section of the river are oriented toward recreation and tourism and the protection of the natural and associated aesthetic and recreational environment is of considerable importance to them. Potential adverse impacts of construction, dredging, and/or altered vessel traffic are understandably of great concern.

Another consequence of this plan is that short-term vessel traffic would be expected to level off, then gradually decrease, as larger vessels up to Class X would predominate over older, smaller vessels. In the long-term, overall decrease in potential vessel transits is expected, but transits by larger vessels would increase with time. Investigations indicate that wave action, propulsion turbidity impacts drawdown (displacement of water) and surge vary and change with the introduction of larger vessels to the system. Fewer overall transits would reduce the frequency of these disturbances caused by larger vessel transits, but the impact of fewer larger ships would have to be investigated in later planning stages.

No water resource facilities (hydroelectric facilities, water intakes, outflows, cable crossings) would be expected to be significantly affected by construction or through plan implementation with usual precautionary measures.

(4) Institutional Feasibility - This plan requires that:

(a) The Canadians implement certain nonstructural measures at the Welland Canal to extend capacity of the existing locks to 1984 or 1992 (depending on percent lock utilization).

(b) The Canadians construct and have fully operational by 1985 or 1994 a new Welland Canal and the remaining St. Lawrence River locks and navigation channels required to be compatible with this plan.

Based on the informal discussion that has taken place, this plan meets with the critical institutional criteria necessary for combined U.S. and Canadian development.

g. Plan RX30.

(1) Description and Technical Assessment - This plan is the same as Plan RX27 in lock dimensions (except the gate sills would be at 32.0 feet) and channel widths, except that the navigation channels are deepened from the existing depth of 27.0 feet below LWD to 30.0 feet below LWD (31.0 feet in rock). The table below shows plan productivity at the constraining lock node

(i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until system capacity is again reached.

Table 14 - Productivity of Plan RX30

| Traffic Forecast | Percent Lock Utilization: 80 Percent | 90 Percent |
|---|---|---|
| Low | 57 Years (1985-2042) | 48 Years (1994-2042) |
| High | NE | NE |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost of Plan RX30 is $1,913,000,000. This equates to an average annual cost of $149,700,000. The benefits calculated for this plan are shown in the table below. This plan does not meet all critical economic criteria, because the net average annual benefits are negative and the B/C ratio is less than one.

Table 15 - Summary of Benefits and Costs for Plan RX30
Numbers are in Millions of Dollars

| Low Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 23.7 | 82.2 | 20.3 | 126.2 | 149.7 | -23.5 | 0.84 |
| 90 Percent Util. | 27.5 | 78.7 | 39.1 | 145.3 | 149.7 | -4.4 | 0.97 |

(3) Environmental and Socioeconomic Assessment - This plan is similar in impacts to RX27, except that the navigation channels would be deepened from 27.0 feet below LWD to 30.0 feet below LWD. This would require approximately 7.7 million cubic yards of material to be removed from the St. Lawrence River channels, in addition to approximately 8.3 million cubic yards needed to widen the channels and the 5.2 million cubic yards for lock construction. Since this plan requires more dredging, it is anticipated that more areas of the St. Lawrence River would be impacted, thus increasing the probability that significant environmental impacts could be realized. Additionally, approximately 21.2 million cubic yards of dredged material would have to be

disposed of, thereby creating the possibility for significant environmental disturbance in the St. Lawrence River area.

With increased depths, vessels with deeper drafts or vessels (up to Class X) more fully loaded would be expected to transit the Seaway. This would further increase the potential Seaway tonnage throughput capacity and associated regional benefits could be realized. On the other hand, construction and dredging costs, activities, and associated potential adverse environmental impacts would increase accordingly. Vessel traffic/passage impacts would be similar to those identified for Plan RX27.

(4) Institutional Feasibility for Plan RX30 - This plan requires that:

(a) The Canadians implement certain nonstructural measures at the Welland Canal to extend capacity of the existing locks to 1984 or 1992 (depending on percent lock utilization).

(b) The Canadians construct and have fully operational by 1985 or 1994 a new Welland Canal and the remaining St. Lawrence River locks and navigation channels compatible with this plan.

(c) The connecting channels and harbors in the Upper Great Lakes are deepened by 1985 or 1994 to be compatible with the new system depth (30.0 feet) proposed in this plan.

Based on informal discussion and assumptions made previously on the upper subsystem, this plan meets all critical institutional criteria for combined U.S. and Canadian development.

h. Plan RX32.

(1) Description and Technical Assessment - This plan has the same lock dimensions (except the lock gate sills would be at 34.0 feet) and channel widths as Plan RX27. The difference in these two plans is the project depth. Plan RX32 calls for deepening from the existing depth of 27.0 feet below LWD to a new minimum depth of 32.0 feet below LWD (33.0 feet in rock). The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and ow long until the system capacity is again reached.

Table 16 - Productivity of Plan RX32

| Traffic Forecast | Percent Lock Utilization | |
|---|---|---|
| | 80 Percent | 90 Percent |
| Low | 61 Years (1985-2046) | 52 Years (1994-2046) |
| High | NE | NE |

NE - Not evaluated for this condition.

(2) Economic Assessment - The total investment cost of Plan RX32 is $2,393,000,000. The benefits for this plan were not calculated as this plan demonstrated low economic productivity potential (see the Evaluation Section that follows).

(3) Environmental and Socioeconomic Assessment - This plan is similar to Plans RX27 and RX30 in that the lock dimensions are the same. The difference lies in that unlike RX30 - deepen to 30.0 feet below LWD - this plan calls for deepening to 32.0 feet below LWD. This requires 16.2 million cubic yards of material to be dredged from the St. Lawrence River compared to 7.7 million cubic yards for Plan RX30. Total dredging for this plan would be approximately 30.1 million cubic yards of material. This plan would cause the same types of impacts outlined in RX27 and RX30, but of a greater magnitude.

(4) Institutional Feasibility - This plan would be similar to Plan RX30 except the new system depth would be 32.0 feet below LWD. Assuming compatible improvements throughout the system, this plan meets all critical institutional criteria.

i. Plan RXI27.

(1) Description and Technical Assistance - This plan consists of construction of new Class XI sized locks to replace the current Eisenhower and Snell locks with no channel deepening. This plan is very similar to Plan RX27, except for lock chamber size. The length of the chamber would be 1,350 feet instead of 1,200 feet, the width would remain the same, and the lock gate sills would be at 30.0 feet below LWD (sufficient for 25.5-foot draft). This longer chamber would be capable of handling a Class XI vessel (1,100 feet long). The channel dredging quantities are identical to Plan RX27. Note that at the present time there are no Class XI sized locks (although the Poe lock can lock through a 1,100-foot vessel with special handling) or Class XI vessels in the GL/SLS System. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 17 - Productivity of Plan RXI27

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | 47 Years (1985-2032) | 44 Years (1994-2038) |
| High | NE | NE |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost for Plan RXI27 is estimated to be $1,086,000,000. This equates to an average annual cost of $85,000,000.

The benefits calculated for this plan are shown in the table below. The total and net benefits for this plan is lower than RX27 because some of the benefits are shared with the Soo Class XI lock. This plan meets all critical economic criteria.

Table 18 - Summary of Benefits and Costs for Plans RXI27
Numbers in Millions of Dollars

| Low Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 23.7 | 53.7 | 16.8 | 94.2 | 85.0 | 9.2 | 1.11 |
| 90 Percent Util. | 27.5 | 46.2 | 33.7 | 107.4 | 85.0 | 22.4 | 1.26 |

(3) Environmental and Socioeconomic Assessment - This plan would have similar impacts to the RX27 Plan. The new locks could accommodate Class XI vessels, thus increasing the chamber length from 1,200 feet to 1,350 feet without increasing the width (115 feet wide). Since the width is the same as RX27, no additional dredging - other than what was outlined in RX27 - would be required in the St. Lawrence River. The only additional excavation would be in the vicinity of lock construction (total lock site dredging equals 5.2 million cubic yards), thus impacting the terrestrial environment slightly more than will RX27.

Increased capabilities to facilitate a slightly larger and longer vessel (Class XI as compared to Class X for Plan RX27) could slightly increase the potential Seaway system tonnage throughput capacity if compatible to the rest of the system. Associated regional socioeconomic benefits could be realized. Impacts of construction would be slightly increased over those identified for Plan RX27; while dredging activities and impacts would be very similar, construction costs would be expected to increase. Vessel traffic/passage impacts would also be similar to those identified for Plan RX27.

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27, and it further requires that a Class XI lock be constructed at the Soo Locks and harbor improvement to handle Class XI ships at the same time as the lower system improvement.

j. Plan RXI30.

(1) Description and Technical Assessment - This plan is the same as Plan RXI27 in lock dimensions (except back gate sills would be at 32.0 feet) and channel widths. The difference between these plans is the design depth of the navigation channels; for Plan RXI27, 27.0 feet (existing system depth); and for this plan, 30.0 feet below LWD (31.0 feet in rock). The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 19 - Productivity of Plan RXI27

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | 57 Years (1985-2042) | 50 Years (1994-2044) |
| High | NE | NE |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment costs for Plan RXI30 is estimated to be $1,964,000,000. This equates to an average annual cost of $153,600,000. The benefits calculated for this plan are shown in the table below. This plan does not meet all of the critical economic criteria because the net average annual benefits are negative, and the B/C ratio is less than one.

Table 20 - Summary of Benefits and Costs for Plan RXI30
Numbers in Millions of Dollars

| Low Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 23.7 | 83.3 | 20.3 | 127.3 | 153.6 | -26.3 | 0.83 |
| 90 Percent Util. | 27.5 | 67.3 | 37.3 | 132.1 | 153.6 | -21.5 | 0.86 |

(3) Environmental and Socioeconomic Assessment - This plan has the same lock dimensions as RXI27; however, this plan would increase the channel depth to 30.0 feet below LWD. Therefore, impacts of this plan would be similar to impacts outlined in both RXI27, which would outline impacts resulting from lock construction, and Plan RX30, which would outline impacts resulting from channel deepening (dredging quantities total 21.7 million cubic yards).

With increased draft, vessels with deeper drafts or vessels (up to Class XI), more fully loaded would be expected to transit the Seaway. This would further increase the potential Seaway tonnage throughput capacity and associated regional benefits could be realized. On the other hand, construction and dredging costs, activities, and associated potential adverse environmental impacts would increase accordingly. Vessel traffic/passage impacts would be similar to those identified for Plan RX27.

(4) Institutional Feasibility - This plan has the same requirements as RXI27, except that deepening the navigation channels and harbors throughout the system is required by the implementation date. This plan then meets all critical institutional criteria.

k. Plan RXI32.

(1) Description and Technical Assessment - This plan is the same as RXI30 (except the lock gate sills would be at 34.0 feet), except that the channels are deepened to 32.0 feet below LWD instead of 30.0 feet. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 21 - Productivity of Plan RXI32

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | 61 Years (1985-2046) | 56 Years (1994-2050) |
| High | NE | NE |

NE - Not evaluated for this condition.

(2) Economic Assessment - The total investment cost of this plan is estimated to be $2,443,000,000. The benefits for this plan were not calculated as this plan did not have high economic productivity potential.

(3) Environmental and Socioeconomic Assessment - Impacts would be similar to those outlined in RX32 and RXI30 (dredging quantities total 30.7 million cubic yards).

(4) Institutional Feasibility - This plan has the same requirements as Plan RXI27, except that deepening the navigation channels throughout the system is required by the implementation date. This plan then meets all critical institutional criteria.

l. Plan RXII27.

(1) Description and Technical Assessment - This plan involves construction of Class XII sized locks to replace the current Eisenhower and Snell locks, with no channel deepening. The lock chamber dimensions for this plan are 1,460 feet long by 145 feet wide (maximum ship size: 1,200 feet long by 130 feet wide), with the lock gate sills at 30.0 feet below LWD (sufficient for 25.5-foot draft). The total lift would be between 83 and 91 feet. Navigation channels would have to be widened to accommodate the new maximum ship beam. A new tunnel would be required to maintain the traffic carried by the existing tunnel under the Eisenhower Lock. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 22 - Productivity of Plan RXII27

| Traffic Forecast | Percent Lock Utilization | |
|---|---|---|
| | 80 Percent | 90 Percent |
| Low | 53 Years<br>(1985-2038) | 48 Years<br>(1994-2042) |
| High | NE | NE |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost of Plan RXII27 is $1,425,000,000. The benefits for this plan were not calculated as this plan did not have high economic productivity potential.

(3) Environmental and Socioeconomic Assessment - This plan involves the construction of two low-lift locks, having dimensions of 1,460 feet long by 145 feet wide. This would require approximately 6.0 million cubic yards of dredging for lock construction, and 13.7 million cubic yards of channel dredging. Anticipated impacts would be similar to RX27, but of an increased magnitude.

Increased capacities to facilitate a larger and longer vessel (Class XII as compared to Class XI for Plan RXI27 or Class X for Plan RX27) could further increase the potential seaway system tonnage throughput capacity if compatible to the rest of the system. This would also facilitate the Upper Lakes system since similar locks are required at the Soo facilities for system compatibility. Also, harbor improvements would be required for the

larger Class XII vessels. Associated additional regional socioeconomic benefits could be realized (reference Plan RX27). Impacts of construction would be slightly increased over those identified for Plans RX27 or RXI27; while dredging activities and impacts would be very similar. Construction costs would be expected to increase. Vessel traffic/passage impacts would also be similar to those identified for Plan RX27.

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27, and it further requries that a Class XII lock be constructed at the Soo locks along with harbor improvements at the same time as the lower system improvement.

m. Plan RXII30.

(1) Description and Technical Assessment - This plan is the same as RXII27 in lock dimensions (except the lock gate sills would be at 32.0 feet) and channel widths. The difference in these plans being the design depth of the navigation channels; for Plan RXII27, 27.0 feet (existing system depth), and for this plan 30.0 feet below LWD (31.0 feet in rock). The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 23 - Productivity of Plan RXII30

| Traffic Forecast | Percent Lock Utilization | |
|---|---|---|
| | 80 Percent | 90 Percent |
| Low | 59 Years (1985-2044) | 52 Years (1994-2046) |
| High | NE | NE |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost for Plan RXII30 is estimated to be $2,361,000,000. The benefits for this plan were not calculated as this plan did not have high economic productivity potential.

(3) Environmental and Socioeconomic Assessment - This plan is very similar to RXII27, except that navigation channels would be deepened from 27.0 feet below LWD to 30.0 feet below LWD (total dredging quantity for this plan is 29.6 million cubic yards). Anticipated impacts would be similar to RX27 and RX30, except of a greater magnitude.

With increased draft, vessels with deeper drafts or vessels (up to Class XII) more fully loaded would be expected to transit the Seaway. This would

further increase the potential Seaway tonnage throughput capacity and associated benefits could be realized. On the other hand, dredging costs, activities, and associated potential adverse environmental impacts would increase accordingly. Vessel traffic/passage impacts would be similar to those identified for Plan RX27.

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27 and it further requires that a Class XII lock be constructed at the Soo locks along with upper system dredging to 30.0 feet (navigation channels and harbors) at the same time as the lower system improvements.

n. Plan RXII32.

(1) Description and Technical Assessment - This plan is the same as Plan RXII27 in lock dimensions (except the lock gate sills would be at 34.0 feet) and channel widths. The difference in these plans being the design depth of the navigation channels; for Plan RXII27, 27.0 feet (existing system depth), and for this plan, 32.0 feet below LWD. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 24 - Productivity of Plan RXII32

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | 63 Years (1985-2048) | 56 Years (1994-2048) |
| High | NE | 42 Years (1984-2026) |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost for Plan RXII32 is $2,950,000,000. The benefits for this plan were not calculated as this plan did not have high economic productivity potential for either the low or high forecast traffic.

(3) Environmental and Socioeconomic Assessment - This plan is the same as RXII27 except that the navigation channel is deepened from 27.0 feet below LWD to 32.0 feet below LWD (total dredging quantity for this plan, 41.8 million cubic yards). Impacts are anticipated to be similar to RX27, RX30 and RXII30, but of a still greater magnitude.

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27, and it further requires that a Class XII lock be constructed at

the Soo Locks along with upper system dredging to 32.0 feet (navigation channels and harbors) at the same time as the lower system improvements.

o. Plan RX27T.

(1) Description and Technical Assessment - This plan involves the "tandem locks" concept to replace the Eisenhower and Snell Locks. The tandem locks usable chambers have a length of 1,860 feet and a width of 115 feet, and for this plan no channel deepening is required. These tandem lock are physically capable of locking through a Class X or Class XI (analysis was limited to Class X) vessel or two Class VII (or smaller vessels) in one cycle. This makes the locks more productive than shorter locks, because the majority of the present fleet and a good portion of the future fleet continues to be made up of vessels of the Class VII size or smaller. Another feature of this lock would be an intermediate set of gates so that the quantity of water used in the locking process would be minimized if one Class VII or smaller vessel was locked through. The lock gate sills would be located at 30.0 feet below LWD (considered sufficient for 25.5-foot draft). Also, a vehicular tunnel would be required under the locks to maintain existing traffic patterns. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal). This identifies when a change would be required for the St. Lawrence Seaway system to be compatible with the Welland Canal and how long until the system capacity is again reached.

Table 25 - Productivity of Plan RX27T

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | NE | NE |
| High | 38 Years (1982-2020) | 44 Years (1984-2028) |

NE - Not evaluated for this condition.

This plan meets all critical technical criteria.

(2) Economic Assessment - The total investment cost for this plan is $1,192,000,000. This equates to an average annual cost of $93,300,000. The benefits calculated for this plan are shown in the table below. This plan meets all critical economic criteria.

Table 26 - Summary of Benefits and Costs for Plan RX27T

| High Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 57.9 | 111.1 | 20.1 | 189.1 | 93.3 | 95.8 | 2.03 |
| 90 Percent Util. | 46.1 | 105.2 | 52.8 | 204.1 | 93.3 | 110.8 | 2.19 |

(3) Environmental and Socioeconomic Assessment - Anticipated impacts would be similar to those outlined for RX27 except that there would be a temporary increase in traffic. This increase would be expected to remain until smaller class vessels, as Class VII vessels are retired and replaced by Class X vessels. Also, more terrestrial excavation would be required, therefore, destroying and disrupting the construction area more than RX27 (total dredging quantity of this plan, 15.3 million cubic yards).

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27. It should be noted that this plan is similar to a plan proposed by the Canadians in a Feasibility Report they prepared in 1967. In other words, the "tandem lock" concept is not new. For a time after the existing Welland Canal was built, a large number of tandem lockages occurred because there were a large number of smaller "canalers" still in operation, that were soon after retired.

p. Plan AVII27.

(1) Description and Technical Assessment - This plan involves "twinning" the existing Eisenhower and Snell locks with the same size locks, and operating them as a parallel system. This is different from prior plans in that the existing system will continue to operate after new locks are constructed. No channel widening or deepening is required.

This plan would allow for a time phasing of improvement in the lower portion of the system. Depending on the percent lock utilization chosen, the Welland Canal would have to be "twinned" by 1985 or 1994. Because the St. Lawrence River locks have excess capacity (because of the relationship of traffic movements between the two lock nodes in the Seaway), they would not have to be twinned immediately. Instead, they could be operated in their present manner until they reach their capacity. At that time, nonstructural improvements would be implemented until a second capacity constraint is reached. Then the St. Lawrence River locks would have to be "twinned" so as not to constrain the lower system. Note that because the maximum ship beam is not changed, no additional dredging for channel widening is required, and no deepening is proposed because the existing locks (lock gate sills at 30.0

feet) cannot be modified to accommodate the deeper draft of vessels. This plan meets all critical technical criteria. The tables below shows plan productivity measured at the St. Lawrence River locks and the Welland Canal.

Table 27 - Productivity of "Twin" Seaway Locks, Plan AVII27, Measured at the St. Lawrence River

| Traffic Forecast | Percent Lock Utilization | |
|---|---|---|
| | 80 Percent | 90 Percent |
| Low | | |
| Nonstructural | 22 Years (1990-2012) | 16 Years (2004-2020) |
| Structural | 38 Years (2012-2050+) | 30 Years (2020-2050+) |
| High | | |
| Nonstructural | 7 Years (1985-1992) | 6 Years (1990-1996) |
| Structural | 48 Years (1992-2040) | 50 Years (1996-2046) |

Table 28 - Productivity of "Twin" Seaway Locks, Plan AVII27, Measured at the Welland Canal

| Traffic Forecast | Percent Lock Utilization | |
|---|---|---|
| | 80 Percent | 90 Percent |
| Low | 65 Years + (1985-2050+) | 56 Years + (1994-2050+) |
| High | 58 Years (1982-2040) | 62 Years (1984-2046) |

NE - Not evaluated for this condition.
\+ - This condition extends beyond the period of analysis.

(2) Economic Assessment - The cost of this plan includes nonstructural improvements, the cost of the new "twin" locks, and an additional O&M cost since more locks are being operated under this plan. The total cost of this plan is $362,000,000. This equates to an average annual cost of $28,300,000. This plan meets all of the critical economic criteria except for the criteria maximizing net benefits of an improvement plan (except for the low forecast at 90 percent lock utilization). Because the plan cannot take credit for vessel utilization savings benefits, it completely foregoes this significant benefit category.

Table 29 - Summary of Benefits and Costs for Plan AVII27
Numbers in Millions of Dollars

| | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| Low Forecast | | | | | | | |
| 80 Percent Util. | 31.0 | 0 | 10.8 | 41.8 | 28.3 | 13.5 | 1.48 |
| 90 Percent Util. | 55.3 | 0 | 25.6 | 80.9 | 28.3 | 52.6 | 2.86 |
| High Forecast | | | | | | | |
| 80 Percent Util. | 68.3 | 0 | 15.9 | 84.2 | 28.3 | 55.9 | 2.98 |
| 90 Percent Util. | 64.5 | 0 | 42.8 | 107.3 | 28.3 | 79.0 | 3.79 |

(3) Environmental and Socioeconomic Assessment - This alternative would only cause construction impacts in the area of Massena, NY (total dredging quantity for this plan is 31.8 million cubic yards). The additional locks would allow for increased traffic (Reference RX27 and RX30), however, the size of the vessels would not increase over present Seaway sized vessels (Class VII). Impacts would be limited to the specific area of construction - Massena, NY - and to a systemwide impact of a greater frequency of ships - increased transits (especially at the high traffic forecast) - passing through the system.

(4) Institutional Feasibility - The development of this plan hinges on similar improvements at Canadian locks in the Welland Canal, and later at their locks in the St. Lawrence River (as the Upper and Lower Beauharnois locks are generally regarded as the "constraint" in the St. Lawrence River portion of the Seaway). Because channel widths and depths are not changed, only the new lock sites would require modifications. Note that this plan does not coincide with any known Canadian improvement proposed to date.

q. Plan AX27.

(1) Description and Technical Assessment - This plan is described as, construction of new "Poe-sized" locks to operate in addition to the existing Eisenhower and Snell Locks. This would result in a parallel system. The

lock chamber dimensions would be 1,200 feet long by 115 feet wide (lock gate sills at 30.0 feet). No channel deepening is required and the depth would remain at 27.0 feet below LWD.

Channel widening would be required to accommodate the new maximum ship beam. The locks would be operated as a parallel system, with all vessels larger than Class VII being assigned to the new, larger lock. At times when there were no vessels larger than the Class VII waiting, vessel assignments would be divided between the existing and new locks. An improved vessel traffic control system would be utilized for this plan. The vehicular tunnel would be required, as in all plans. The table below shows plan productivity at the constraining lock node (i.e., the Welland Canal).

Table 30 - Productivity of Plan AX27

| Traffic Forecast | Percent Lock Utilization: 80 Percent | Percent Lock Utilization: 90 Percent |
|---|---|---|
| Low | NE | NE |
| High | 50 Years (1982-2032) | 54 Years (1984-2038) |

NE - Not evaluated for this plan.

(2) Economic Assessment - The total cost of this plan is estimated to be $1,104,000,000, which includes the present worth of the additional O&M costs, and the vessel traffic control system. This equates to an average annual cost of $86,400,000. This plan meets all critical economic criteria.

Table 31 - Summary of Benefits and Costs for Plan AX27

| High Forecast | Transportation Rate Savings | Vessel Utilization Savings | Vessel Delay Savings | Total Average Annual Benefits | Average Annual Charges | Net Average Annual Benefits | Benefit/ Cost Ratio |
|---|---|---|---|---|---|---|---|
| 80 Percent Util. | 57.9 | 111.1 | 23.6 | 192.6 | 86.4 | 106.2 | 2.23 |
| 90 Percent Util. | 46.1 | 104.5 | 55.4 | 206.0 | 86.4 | 119.6 | 2.38 |

(3) Environmental and Socioeconomic Assessment - Impacts would be very similar to those outlined in AVII27 except that the number of total vessel transits is significantly smaller, and to impacts in RX27 pertaining to channel widening and socioeconomic impacts (total dredging quantity for this plan is 13.0 million cubic yards).

(4) Institutional Feasibility - This plan has the same requirements as Plan RX27, and in addition, the Canadians must be willing to maintain and operate a parallel system. It also requires that a second Poe sized lock be built at the Soo locks at some point in the future so that the upper system does not become constrained. This plan then meets all critical institutional criteria.

r. No-Action Plan.

(1) Description and Technical Assessment - The "No-Action" plan means that no Federal action is taken to change the existing system. In this case, the St. Lawrence Seaway Development Corporation can and is expected to make some minor nonstructural improvements under their operations and maintenance authority. It is assumed that such changes would not affect the capacity of the St. Lawrence River lock because these changes have little relative capacity expansion capability, and also because the U. S. locks are not considered to be the constraining locks in the St. Lawrence River. Therefore, this plan is used as the basis for comparison against which alternate improvement plans are evaluated.

(2) Economic Assessment - This plan is assumed to have no costs and no additional benefits over the existing system when capacity is reached. However, it does not meet the critical economic criteria because there are no additional benefits and a 50-year economic life will not be approached. From the analysis in this study, the current lower system will reach capacity (at the constraining lock node, the Welland Canal) between 1984 and 1994 (depending on traffic forecast assumed).

(3) Environmental and Socioeconomic Assessment - If this alternative was selected, the Federal Government would take no action to improve the navigation system. Changes to the biological environment would generally be projected as being beneficial. With improving water quality - which influences and affects many aquatic and terrestrial species - aquatic habitats would be viewed as having the potential to improve; therefore, favoring biological populations. However, the no-action alternative would allow the navigation system to reach capacity in the near future. This would cause increased congestion at restricted areas in the system which would contribute to delays to shippers and increased costs to the nation. The no-action alternative also limits the growth of the system and would cause a diversion of goods to other modes of transportation. These impacts on the system could adversely effect socioeconomic conditions in the Great Lakes Region.

(4) Institutional Feasibility - "No-Action" by the U.S. could result in either "no-action" by the Canadians, or a move by the Canadians to build an all-Canadian Seaway. This possibility exists because the Canadians can bypass the Eisenhower and Snell Locks by building a new lock at Cornwall, Ontario. If this took place, the U.S. would only have a small interest in the Seaway, that being the navigation channels in U.S. waters. This may not be desirable considering the importance of this waterway to national security, as well as the potential benefits which could be lost.

s. Regional Economic Impacts.

This section is very qualitative in nature, and was not performed in a plan specific manner. Therefore, it is presented here for general information. A separate analysis was conducted of the likely consequences of alternate plans which would increase the transport capability of the existing locks and channels in the GL/SLS. Individual study areas including energy, changes in industrial production, income and employment effects, social and intermodal impacts were addressed. A brief overview of each follows.

(1) Energy Impacts - Individual energy consumption characteristics for overland modes such as railroads, trucks in addition to barge, lake vessels, and ocean-going general cargo vessels were derived on a ton-mile basis. Secondary sources of data were extensively used. Adjustments in point-to-point distances to reflect specific circuit factors to make modal comparisons as accurate as possible were performed.

A candidate plan of improvement under the low traffic scenario was used to compare the energy savings per ton. Additional physical capacity at the St. Lawrence River locks would allow more tons to be accommodated relative to the without-project condition. Four major commodity groupings (iron ore, coal, grain, stone and other bulk) were evaluated during the project evaluation period. Although one commodity group (grain) has an energy penalty associated with a Great Lakes routing, the total energy savings are positive for the specific alternate plan evaluated. The net energy savings would vary with the productivity of individual plans of improvement and the particular traffic forecasts under consideration.

(2) Changes in Industrial Production - Changes in the existing level of transportation costs per ton for major commodities were investigated to determine the likely change in overall demand for the commodity. The analysis developed estimates of fixed and variable costs to transport or produce a unit of raw material (grain) or intermediate (raw steel) products.

A hypothetical reduction of 20 percent in the current Great lakes transportation cost per ton was used as an upper limit of the future impact which may accrue from larger locks and/or deeper channels. This percent reduction was identified during preliminary investigations into changes in constructed costs per ton for a hypothetical maximum vessel size which might operate at drafts up to 30 feet. Major commodities such as grain, coal, and iron ore would experience only a 1 to 4 percent reduction in the delivered prices of raw materials or production costs for intermediate goods in the market place if future vessel costs per ton declined by 20 percent. The general conclusion of this portion of the report was that no significant change in industrial production or demand for raw materials would result from larger lock sizes.

(3) Regional Economic Impacts - Changes in the level of port activity which would occur as a result of an increase in the physical capacity of existing locks was evaluated. Income and employment at individual ports was quantified using generalized factors based upon a similar study for a major East Coast harbor. Each additional ton serviced at these harbors was

expected to increase income levels by $1.50 for each ton of bulk and $32.00 for each ton of general cargo. Employment impacts were estimated at 60 additional jobs for every million tons of bulk cargo handled, while general cargo was responsible for 1,450 jobs per million tons.

A regional income multiplier of 1.4, based upon U.S. Department of Commerce studies, was the basis for determining the overall increase in regional economic activity.

A matrix of changes in traffic levels at each major port was derived from the additional tonnage serviced by a particular plan of improvement. Application of employment and income ratios to individual subtotals of bulk and general cargo produced estimates of the increase in regional income and employment.

A conclusion was reached that any alternate plan which would allow the existing locks to accommodate an increasing level of commercial traffic would make positive contribution to the level of regional income and employment.

(4) Intermodal Impacts - Changes in the net revenue of various segments of the U.S. freight carrier industry which presently serves the Great Lakes Region were evaluated. The transportation sectors which might be affected include: railroads, motor carriers, barge operators and the U.S. Flag Ship Great Lakes and foreign trade fleets.

The evaluation was restricted to the future change in U.S. transportation sectors, therefore, a sequence of steps which adjusted for non-U.S. carriers was performed. Improvements to existing locks which would allow a greater annual volume to be processed at the locks in the lower Great Lakes would increase net revenues per ton for laker vessels and motor carriers (trucks) at the expense of railroads, barges, and general cargo tidewater vessels.

Individual improvement plans which would provide large increases in physical capacity would also cause the highest degree of modal revenue shifts from alternate transportation systems to Great Lakes vessel operators.

The conclusions reached during the study of the regional economic impacts cannot be generalized to specific plans of improvement and the individual maximum size vessels and operating drafts which might be accommodated. However, proposed plans of improvement can be grouped into two types: plans which allow more of the same size vessel to continue to operate and, plans which allow larger (i.e., 1,000-foot X 105-foot up to 1,200-foot X 130-foot) vessels to navigate through locks and channels. Both sizes are generally compared with the "no-action" alternative in the summary table in the Evaluation Section following.

t. Impacts on Recreational Boating.

This section is qualitative in nature, and was not performed in a totally plan specific manner. Therefore, it is presented here for general information. An investigation was performed to evaluate existing and future impacts of commercial vessel movements upon recreational boating activities. This study consisted of an extensive literature search of available secondary data

on recreational use patterns of the St. Lawrence River Valley. The river was subsequently divided into three geographic reaches based upon the concentration of existing marina and related facilities, boating use patterns for 1981 and unique physical characteristics of the St. Lawrence River.

Field investigations were performed to document the location, type and size of existing marina facilities and to establish the basis for an evaluation of the most probable interaction between commercial vessels and recreational small craft. Related information on vessel accidents, physical damage and the probability of future conflicts between commercial interests and recreational boaters for access to the navigation channels and related facilities (i.e., locks) was obtained during December 1981.

Six evaluation criteria were identified as a result of the field interviews:

- Physical damage to existing recreational boating facilities and shore-based recreational structures due to commercial ship-generated waves.

- Congestion near locks and competition for lock transits between commercial ships and recreational boats.

- Congestion on the river between commercial ships and recreational boats.

- Conflicts between cruising recreational boats and commercial ships.

- Impacts of commercial shipping on recreational fishing and hunting from small craft.

- Impacts of commercial shipping on reliable private transportation for island residents.

Baseline conditions (without-project) were developed for comparison with a plan of improvement which would allow navigation of larger vessels. This preliminary plan was evaluated for both high and low traffic forecasts. The plan was further refined in terms of implementation; either in conjunction with a capacity condition at the Welland Canal or at a point in time when the existing St. Lawrence River locks would become physically constrained. Each combination of implementation dates and levels of traffic will produce a unique impact in the future. The degree of impact was quantified as a change in the estimated number of average daily transits for the peak warm weather months (June, July, August), relative to the appropriate baseline condition.

A matrix of baseline conditions, with-project conditions and the net change in each of the six evaluation criteria were documented. Changes in each evaluation criteria are identified for each of the three reaches and three seasonal periods (i.e., spring, summer and fall). Discussion was limited to the most significant areas of change between existing and future conditions.

General discussion and recommendations in the report are summarized below by reach:

Reach 1 (Tibbetts Point to Chippewa Point) - Recreational boating, boating facilities, and narrow river sections, island residences, are concentrated in this area. These factors combine to increase the possibility of ship-generated waves causing damage to boating facilities and structures, conflicts between cruising recreational boats and commercial ships and impacts on reliable private transportation for island residents.

Reach 2 (Chippewa Point to the Head of Iroquois Island) - Commercial shipping activity has no or low negative impacts on recreational boating in this reach. There may be a medium negative impact on recreational fishing and hunting from small craft for certain plans of improvement under the high traffic forecast alternative.

Reach 3 (Head of Iroquois Island to International Border) - Conclusions for this area are similar to Reach 2.

The Contractor reached a general conclusion that larger vessels operating on the river should have no major direct impacts upon recreational boating. Certain plans may actually result in fewer annual transits during peak warm-weather months for a period of time following completion of the proposed project. The attractiveness of the river may increase slightly because fewer transits are projected to occur after larger locks are built.

Indirect, long-term consequences following construction of the larger locks were generally indicated and briefly discussed. Disruption to the existing biological resources would have an adverse economic impact depending upon the degree of impact, the sensitivity of recreationists to changes in natural resources, and the availability of the more desirable recreational resources elsewhere.

Recommendations for further study included:

- Biological assessment of the impact of larger locks and larger ships on existing fish and wildlife resources should be undertaken,

- Investigate physical effects of larger vessel operations upon recreational boating and related facilities and structures, and

- Survey of the attitudes of recreational boaters towards commercial vessel activity.

The six categories of impacts to recreational boating were judgementally reduced to four, and are shown in the Summary Table in the Evaluation Section following.

EVALUATION

In the last section, 13 plans were assessed for their adequacy in meeting the planning objectives, and the technical, economic, environmental and

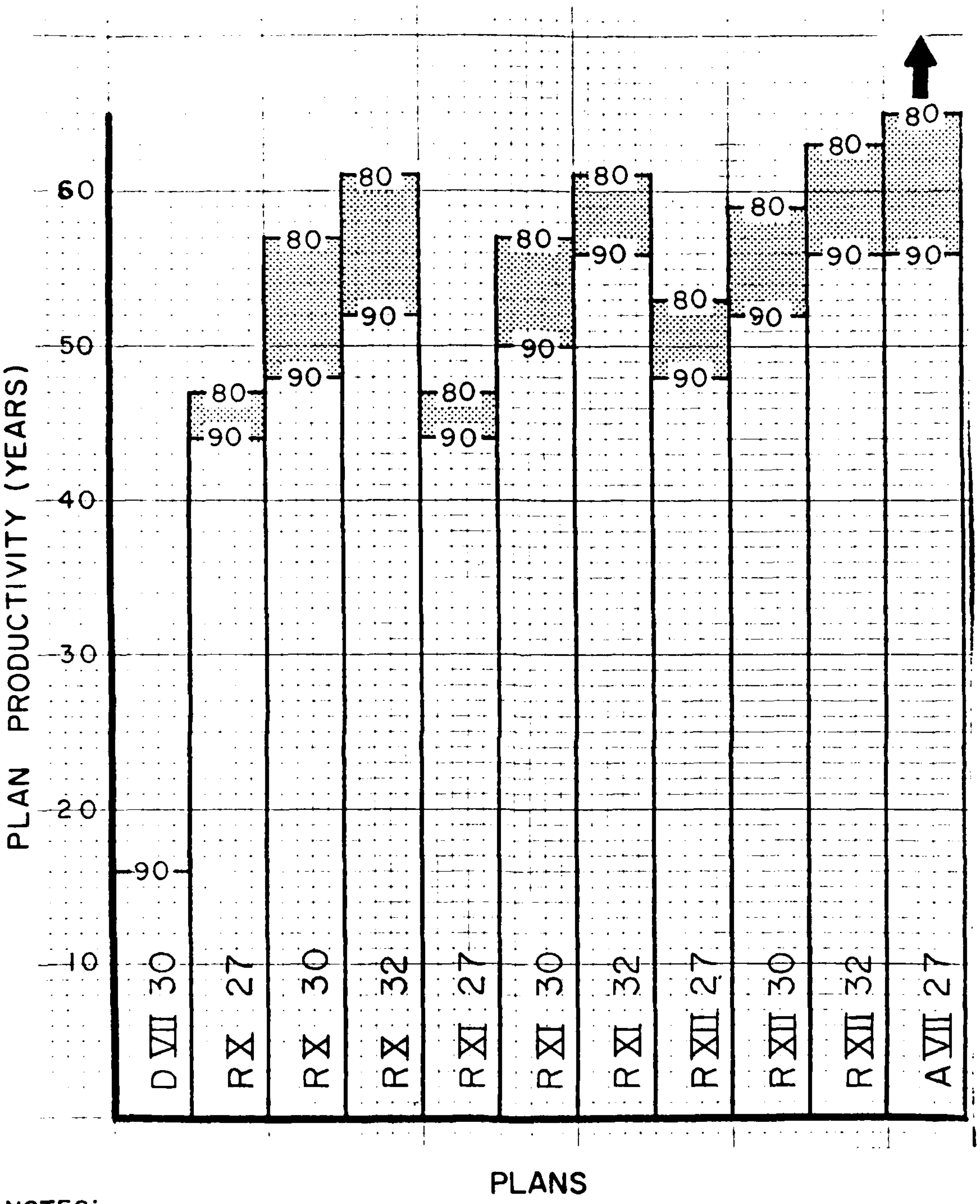
socioeconomic, and institutional criteria. Selected plans were tested for both the low and high traffic forecasts, while others were only tested for one or the other of these forecasts. This section will initially screen the 13 plans for their productivity relative to the traffic forecast used. Eleven plans were considered for the low traffic forecast, and five plans were considered for the high traffic forecast.

a. Low Traffic Forecast Plans.

In all, eleven plans were tested against this traffic forecast. The types of plans considered were: deepening channels, replacing existing locks by larger locks at existing or deeper channel depths, or addition of "twin" locks at the existing channel depth. As identified earlier, deepening channels (Plan DVII30) will not meet certain critical technical criteria, but is shown in this section for comparison purposes. Plans RX27, RXI27, and RXII27 tested the feasibility of replacing the existing locks with new larger locks. Plans RX30, RX32, RXII30, and RX32 looked at replacement with larger locks and deepening channels. Finally, Plan AVII27 looked at "twinning" the existing locks so that, in effect, a parallel system (similar to the flight locks at the Welland Canal) would be in place, which could move something on the order of twice the number of vessel transits, and hence, twice the tonnage. Note that several simplifying assumptions had to be made at this point for analysis of Plan AVII27 to take place. The lock capacity model was not set up to test parallel lock systems for the Welland Canal or St. Lawrence River locks. Therefore, an adjustment to the lock service time (for Classes IV-VII) was required to allow the model to "simulate" parallel locks. The average of the locking times for the old and new systems were reduced by 50 percent to simulate a parallel lock condition. For this plan, the St. Lawrence River locks, are in turn, allowed to reach capacity. This is followed by implementation of Plan AVII27, which includes nonstructural to maximum utility, and later when the secondary capacity date is reached the parallel "twin" locks are built.

The eleven plans were compared in a number of ways to determine their relative worth. First of all, each plan's productivity was measured. The plan productivity is defined as the incremental number of years the plan extends the capacity of the constraining lock node (in this case, the Welland Canal). Figure 30 compares the plan productivity of the 11 plans. Only Plan DVII30 fails to meet the economic criteria requiring the plan approach or exceed an economic life of 50 years. Also, note that the plan productivity for the 80 and 90 percent lock utilizations are shown for all plans. Plans RX27 and RXI27 are considered sufficiently close to the goal of 50 years to be considered further in this evaluation.

The next step in testing the remaining ten plans was development of individual plan costs. Table 32 gives a summary of the total investment cost for each of the ten plans. At this point, it was decided that the economic efficiences of these plans should be tested to determine whether larger ships and/or deeper channels were more productive. To compare these ten plans, the economic productivity of each plan was measured and compared. Economic productivity is defined as the incremental tons the planned improvement can




NOTES:

1. ALL PLAN PRODUCTIVITIES SHOWN ARE FOR THE CONSTRAINING LOCK NODE (i.e. WELLAND CANAL).
2. PLAN A VII 27 GOES TO THE YEAR 2050 AND BEYOND (EXTENDS OUT LONGER THAN SHOWN).
3. 80 90 THE SYMBOL SHOWS THE RANGE OF PLAN PRODUCTIVITY FOR 80 AND 90 PERCENT LOCK UTILIZATIONS.

FIGURE 30 LOW TRAFFIC FORECAST, PLAN PRODUCTIVITY

Table 32 - U.S. Costs of Low Traffic Forecast Plans (St. Lawrence River)
Investment (1) Costs in Millions of Dollars (March 1982 Price Levels)

| Lock Plan / Channel Depth (feet below LWD) | Replace Existing System | | | | New Locks Plus Existing System | |
|---|---|---|---|---|---|---|
| | 115' W X 1,200' L Locks - Class X (2) | 115' W X 1,350' L Locks - Class XI | 145'W X 1,460' L Locks - Class XII | Tandem 115' W X 1,800' L Locks 2 - Class VII or 1 Class X | "Twin" 80' W X 860' L Locks - 2 Class VII | 115' W X 1,200' L Locks - 1 Class VII or 1 Class X |
| 27.0 (26.0 Draft) (6) | RX27 (3) 1,040 | RXI27 1,086 | RXII27 1,425 | N.E. (4) | AVII27 362 (5) | N.E. |
| 30.0 (28.0 Draft) (7) | RX30 1,913 | RXI30 1,964 | RXII30 2,361 | N.E. | N.E. | N.E. |
| 32.0 (30.0 Draft) (7) | RX32 2,393 | RXI32 2,443 | RXII32 2,950 | N.E. | N.E. | N.E. |

(1) Total Investment Cost including both Federal and non-Federal First Costs.

(2) Vessel Size: Class VII - 75' W X 730' L; Class X - 105' W X 1,000' L; Class XI - 105' W X 1,100' L' and Class XII - 130' W X 1,200' L.

(3) RX27 - Scenario number, typical.

(4) N.E. - Not evaluated for this traffic forecast.

(5) Includes costs of nonstructural improvements and additional Operations and Maintenance.

(6) Design draft is 25.5 feet with seaway operating agency approved draft of 26.0 feet.

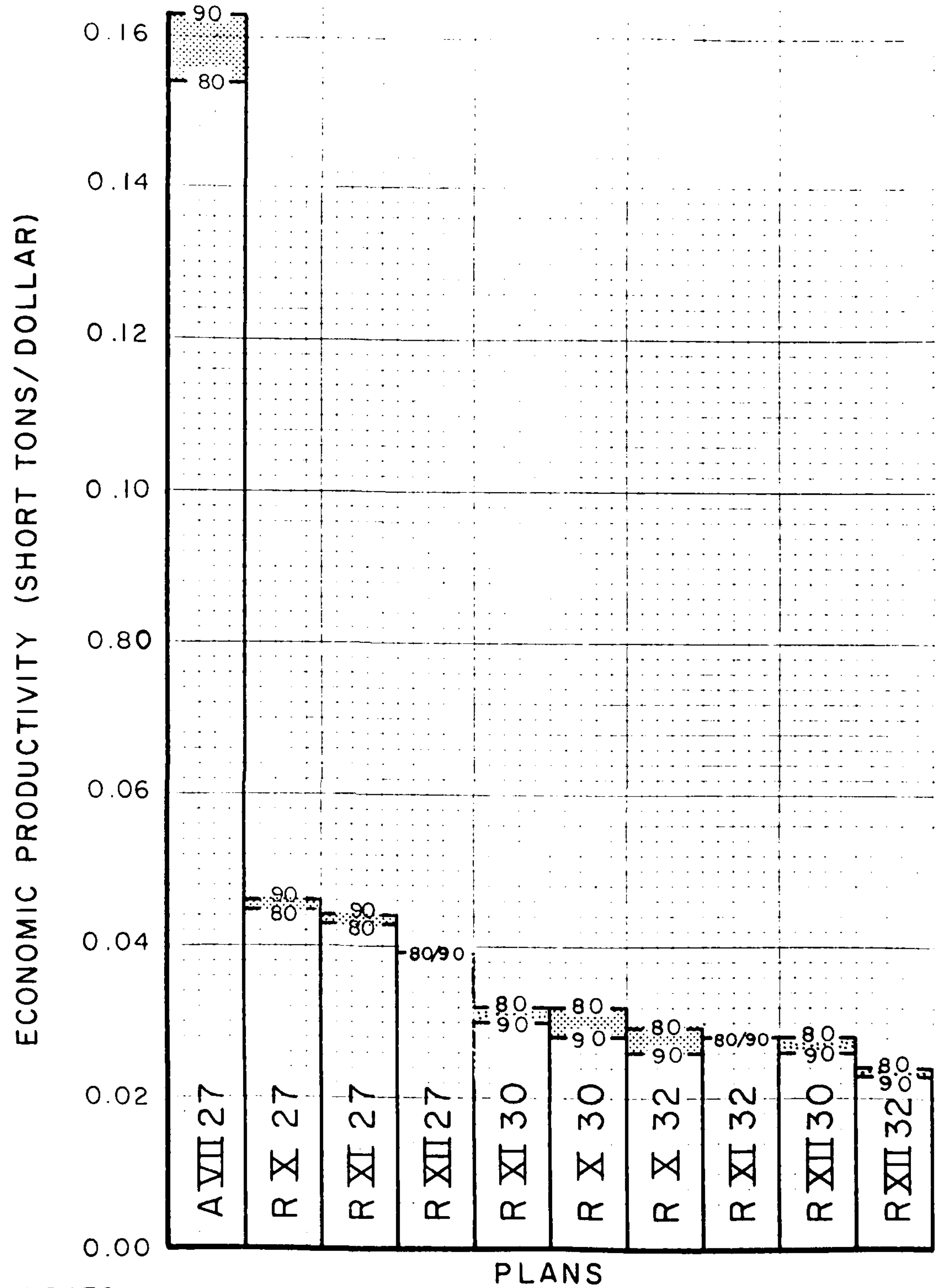
(7) Present channel design criteria recommends a 2-foot under keel clearance for any deepening plan.

carry divided by that plan's cost. Figure 31 compares the economic efficiency of the ten plans. Note that each plan is evaluated at both the 80 and 90 percent lock utilizations.

The results of the comparison of economic productivity provides the basis for reducing the number of plans to be considered further in this evaluation. Observation of Figure 31, shows that increasing lock size and channel depths becomes less productive on a tons/dollar basis. Plan AVII27 has the highest economic productivity because it includes no channel widening, channel deepening, or harbor improvement costs. This is because the current fleet is utilized and maximum allowable ship size is unchanged. This plan does, however, forego any vessel producitvity savings (economics of scale) that would be realized by building a larger lock to accommodate larger vessels. An economic benefit analysis is required to determine if this plan or other plans maximize net benefits. Plans RX27 and RXI27 are very similar in their economic productivity, and are considerably higher than the remaining seven plans. Plans RX30 and RXI30 would involve deepening of the navigation channels in addition to building larger locks. To present as complete an analysis as possible, it was determined that the five aforementioned plans should be fully tested in this evaluation section. Therefore, a full comparison of benefits and costs, environmental and socioeconomic, and institutional effects is in order. Table 33, is a summary of the effects of these five plans (AVII27, RX27, RXI27, RX30, and RXI30) and a comparison to the "No Action" Plan. The remaining five plans are considered to be somewhat similar to these selected five plans in other parameters. However, larger locks and deeper channels are generally associated with increasing levels of environmental impacts due to increased amounts of dredging and disposal required. It does not appear these impacts can be balanced by any significant economic or other off setting criteria. Therefore, the four remaining plans RX32, RXI32, RXII27, and RXII32 are eliminated from any further detailed study.

b. High Traffic Forecast Plans.

Because of the higher tonnage level, more "exotic" plans were required during the analyses to achieve the goal of approaching or exceeding a 50-year economic life. Five new plans were tested against the high traffic forecast. These plans are: RX27, RXII32, RX27T, AVII27, and AX27. Plan RX27 involves replacing the existing locks with larger locks. Plan RXII32 involves replacing the existing locks with larger locks and deeper channels. Plan RX27T investigates the concept of a "tandem" lock. "Tandem" means that a long lock(s) (1,800 feet) is built which can handle either one Class X vessel (1,000 feet in length) or two "Seaway-sized" vessels (Class VII: 730 feet in length). It has the advantages of accommodating Class X vessels, and processing more Class VII vessels than a Class X lock. This concept was heavily used during the first few years after the existing Seaway Locks were opened. Until old "canalers" (200 to 300 feet in length) were retired, and replaced by larger vessels many "tandem lockages were used. Plans AVII27 and AX27 would create a parallel system at each lock location. Under Plan AVII27, ships (limited to Class VII or smaller) could utilize either lock in any upbound or downbound direction. Plan AX27 allows similar flexibility of vessel movements except that all vessels larger than Class VII must be assigned to the new Class X locks.




NOTES:

1. ALL ECONOMIC PRODUCTIVITIES SHOWN ARE MEASURED AT THE CONSTRAINING LOCK NODE (i.e. THE WELLAND CANAL).
2. THE SYMBOL [90/80] SHOWS THE RANGE OF PLAN ECONOMIC PRODUCTIVITIES FOR THE 80 AND 90 PERCENT LOCK UTILIZATION TESTS.

FIGURE. 31 LOW TRAFFIC FORECAST: ECONOMIC PRODUCTIVITY OF PLANS

Table 33 - Summary of Effects of Plans

| | Low Traffic Forecast Plans | | | | | Low and High | High Traffic Forecast Plans | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plan RX27 | Plan RX127 | Plan RX30 | Plan RY130 | Plan AVII27 | No-Action | Plan AVII27 | Plan AX27 | Plan [illegible] |
| A. Plan Description | Construction of Class X locks to replace the existing locks at the current system depth (27.0 feet). Channel widening is required for the new maximum ship beam. Improvements are made with the Welland Canal. | Construction of Class XI locks to replace the existing locks at the current system depth (27.0 feet). Channel widening is required for the new maximum ship beam. Improvements are made with the Welland Canal. | Construction of Class X locks to replace the existing locks, and deepen the system channels to 30.0 feet. Channel widening is required for the new maximum ship beam. Improvements with the Welland Canal. | Construction of Class XI locks to replace the existing locks, and deepen the system channels to 30.0 feet. Channel widening is required for the new maximum ship beam. Improvements with the Welland Canal. | Add nonstructural improvements to maximum utility. Following that, construct "twin" (Class VII) locks parallel to the existing locks. Operate existing and new locks as a parallel system at the current system depth (27.0 feet). | Do nothing (Without Conditions) | Add nonstructural improvements to maximum utility. Following that, construct "twin" (Class VII) locks parallel to the existing locks. Operate existing and new locks as a parallel system at the current system depth (27.0 feet). | Construction of Class X locks to operate as a parallel system with the existing locks at the current system depth (27.0 feet). Channel widening is required for the new maximum ship beam. Improvements are made concurrently with the Welland Canal. | Construction of "tandem" [illegible] the existing [illegible] current system [illegible] (27.0 feet). [illegible] widening is required for the new maximum ship beam. Improvements are made concurrently with the Welland Canal. |
| 1. Implementation Date at St. Lawrence River | | | | | | | | | |
| 80% Lock Utilization | 1985 | 1985 | 1985 | 1985 | 1990 (1), 2012 | | 1985 (1), 1992 | 1982 | 1992 |
| 90% Lock Utilization | 1994 | 1994 | 1994 | 1994 | 2004 (1), 2020 | | 1990 (1), 1996 | 1984 | 1994 |
| B. Significant Impacts | | | | | | | | | |
| 1. National Economic Development (NED) (Reference Economic Appendix B) | | | | | | | | | |
| a. Beneficial Impacts | | | | | | | | | |
| (1) Total Annual Benefits (in Dollars) | | | | | | | | | |
| 80% Lock Utilization | 116,600,000 | 94,200,000 | 126,200,000 | 127,300,000 | 41,800,000 | 0 | 84,200,000 | 192,600,000 | 199,1[illegible] |
| 90% Lock Utilization | 119,700,000 | 107,400,000 | 145,300,000 | 132,100,000 | 80,900,000 | 0 | 107,300,000 | 206,000,000 | 204,100,000 |
| b. Adverse Impacts | | | | | | | | | |
| (1) Total Investment Cost (in Dollars) | | | | | | | | | |
| (a) Federal | 1,026,000,000 | 1,069,000,000 | 1,732,000,000 | 1,778,000,000 | 362,000,000 | 0 | 362,000,000 | 1,090,000,000 | 1,1[illegible]8,000,000 |
| (b) Non-Federal | 14,000,000 | 17,000,000 | 181,000,000 | 186,000,000 | 0 | 0 | 0 | 14,000,000 | 14,000,000 |
| (c) Total | 1,040,000,000 | 1,086,000,000 | 1,913,000,000 | 1,964,000,000 | 362,000,000 | 0 | 362,000,000 | 1,104,000,000 | 1,192,[illegible] |
| (2) Annual Charges | | | | | | | | | |
| (a) Federal | 80,300,000 | 83,600,000 | 135,500,000 | 139,100,000 | 28,300,000 | 0 | 28,300,000 | 85,300,000 | 92,200,000 |
| (b) Non-Federal | 1,100,000 | 1,300,000 | 14,200,000 | 14,600,000 | 0 | 0 | 0 | 1,100,000 | 1,1[illegible] |
| (c) Total | 81,400,000 | 84,900,000 | 149,700,000 | 153,700,000 | 28,300,000 | 0 | 28,300,000 | 86,400,000 | 93,[illegible] |
| (3) Dredging (c.y.) | | | | | | | | | |
| (a) Lock Site | 4,700,000 | 5,200,000 | 5,200,000 | 5,700,000 | 3,800,000 | 0 | 3,800,000 | 4,700,000 | 7,000,[illegible] |
| (b) Channel Widening | 8,300,000 | 8,300,000 | 8,300,000 | 8,300,000 | 0 | 0 | 0 | 8,300,000 | 8,[illegible] |
| (c) Channel Deepening | 0 | 0 | 7,700,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| c. Economic Efficiency | | | | | | | | | |
| (1) Economic Productivity (short tons/$) | | | | | | | | | |
| 80% Lock Utilization | 0.045 | 0.043 | 0.032 | 0.032 | 0.144 | - | 0.304 | 0.087 | [illegible] |
| 90% Lock Utilization | 0.046 | 0.044 | 0.028 | 0.030 | 0.163 | - | 0.320 | 0.091 | [illegible] |
| (2) Net Annual Benefits (in Dollars) | | | | | | | | | |
| 80% Lock Utilization | 35,200,000 | 9,300,000 | -23,500,000 | -26,400,000 | 13,500,000 | 0 | 55,900,000 | 106,200,000 | 95,[illegible] |
| 90% Lock Utilization | 38,300,000 | 22,500,000 | - 6,400,000 | -21,600,000 | 52,600,000 | 0 | 79,000,000 | 119,600,000 | 110,800,000 |
| (3) B/C Ratio | | | | | | | | | |
| 80% Lock Utilization | 1.43 | 1.11 | 0.84 | 0.81 | 1.48 | - | 2.98 | 2.23 | 2.03 |
| 90% Lock Utilization | 1.47 | 1.27 | 0.97 | 0.86 | 2.86 | - | 3.79 | 2.38 | 2.19 |

Table 33 - Summary of Effects of Plans (Cont'd)

**Low Traffic Forecast Plans**

| | Plan RX27 R ST | Plan RX27 R LT | Plan RX27 L ST | Plan RX27 L LT | Plan RX127 R ST | Plan RX127 R LT | Plan RX127 L ST | Plan RX127 L LT | Plan RX1 R ST | Plan RX1 R LT | Plan RX1 L ST | Plan RX1 L LT | Plan AX130 R ST | Plan AX130 R LT | Plan AX130 L ST | Plan AX130 L LT | Plan AVI127 R ST | Plan AVI127 R LT | Plan AVI127 L ST | Plan AVI127 L LT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 Environmental Quality (EQ) Social-Economic Considerations (SWB) Regional Development (RED) (Reference Environmental Appendix A) (Reference Economic Appendix B) | | | | | | | | | | | | | | | | | | | | |
| a. Physical Environment | | | | | | | | | | | | | | | | | | | | |
| (1) Air Quality | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | 0 | - | - | - |
| (2) Water Quality | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | 0 | - | - | - |
| (3) Topography | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |
| (4) Erosion | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | 0 | NK | - | NK |
| b. Natural Environment | | | | | | | | | | | | | | | | | | | | |
| (1) Fish | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | 0 | 0 | - | NK |
| (2) Wildlife | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | 0 | 0 | - | NK |
| (3) Wetlands | NK | NK | - | NK | NK | NK | - | NK | NK | NK | - | NK | NK | NK | - | NK | 0 | 0 | - | 0 |
| (4) Vegetation | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | - | NK | 0 | 0 | - | NK |
| (5) Benthos | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | 0 | 0 | - | 0 |
| (6) Threatened & Endangered Species | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | 0 | 0 | 0 | 0 |
| (7) Prime & Unique Farmland | NK | NK | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 | 0 | 0 | 0 | 0 |
| (8) Wild & Scenic Rivers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (9) Coastal Zone | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | 0 | 0 | 0 | 0 |
| c. Human Environment | | | | | | | | | | | | | | | | | | | | |
| (1) Noise | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | 0 | - | - | - |
| (2) Aesthetics | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 |
| (3) Population (Mobility/Displacement) | NK | + | 0 | + | NK | + | 0 | + | NK | + | 0 | + | NK | + | 0 | + | NK | + | 0 | + |
| (4) Employment and Income | + | + | + | 0 | + | + | + | 0 | + | + | + | 0 | + | + | + | 0 | + | + | + | 0 |
| (5) Land Use | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + |
| (6) Man-Made Resources | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + |
| (7) Transportation (Intermodel) | | | | | | | | | | | | | | | | | | | | |
| (a) Navigation | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + |
| (b) Tug & Barge | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - |
| (c) Railroads | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 |
| (d) Motor Carriers | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 |
| (e) Construction Site | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | 0 |
| (8) Energy | - | + | - | 0 | - | + | - | 0 | - | + | - | 0 | - | + | - | 0 | - | + | - | 0 |
| (9) Business & Industry | + | + | + | 0/+ | + | + | + | 0/+ | + | + | + | 0/+ | + | + | + | 0/+ | + | + | + | 0/+ |
| (10) Recreation | | | | | | | | | | | | | | | | | | | | |

**Low and High No-Action; High Traffic Forecast Plans**

| | No-Action R ST | No-Action R LT | No-Action L ST | No-Action L LT | Plan AVI127 R ST | Plan AVI127 R LT | Plan AVI127 L ST | Plan AVI127 L LT | Plan AX27 R ST | Plan AX27 R LT | Plan AX27 L ST | Plan AX27 L LT | Plan RX2? R ST | Plan RX2? R LT | Plan RX2? L ST | Plan RX2? L LT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 Environmental Quality (EQ) Social-Economic Considerations (SWB) Regional Development (RED) (Reference Environmental Appendix A) (Reference Economic Appendix B) | | | | | | | | | | | | | | | | |
| a. Physical Environment | | | | | | | | | | | | | | | | |
| (1) Air Quality | 0 | + | 0 | + | 0 | - | - | - | - | - | - | - | - | + | - | + |
| (2) Water Quality | 0 | + | 0 | + | 0 | - | - | - | - | - | - | - | - | + | - | + |
| (3) Topography | 0 | 0 | 0 | 0 | A | A | A | A | A | A | A | A | A | A | A | A |
| (4) Erosion | 0 | 0 | 0 | 0 | 0 | NK | - | NK | - | NK | - | NK | - | NK | - | NK |
| b. Natural Environment | | | | | | | | | | | | | | | | |
| (1) Fish | 0 | + | 0 | + | 0 | NK | - | NK | - | NK | - | NK | - | NK | - | NK |
| (2) Wildlife | 0 | + | 0 | + | 0 | NK | - | NK | - | NK | - | NK | - | NK | - | NK |
| (3) Wetlands | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 | NK | NK | - | NK | NK | NK | - | NK |
| (4) Vegetation | 0 | 0 | 0 | 0 | 0 | NK | - | NK | - | NK | - | NK | - | NK | - | NK |
| (5) Benthos | 0 | + | 0 | + | 0 | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 |
| (6) Threatened & Endangered Species | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NK | NK | NK | NK | NK | NK | NK | NK |
| (7) Prime & Unique Farmland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 |
| (8) Wild & Scenic Rivers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (9) Coastal Zone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NK | NK | NK | NK | NK | NK | NK | NK |
| c. Human Environment | | | | | | | | | | | | | | | | |
| (1) Noise | 0 | - | 0 | - | 0 | - | - | - | - | - | - | - | - | + | - | + |
| (2) Aesthetics | NK | NK | 0 | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | [illegible] |
| (3) Population (Mobility/Displacement) | 0 | - | 0 | - | NK | + | 0 | + | NK | + | 0 | + | NK | + | 0 | + |
| (4) Employment and Income | 0 | - | 0 | - | + | + | + | 0 | + | + | + | 0 | + | + | + | [illegible] |
| (5) Land Use | NK | NK | 0 | NK | - | + | - | + | - | + | - | + | - | + | - | + |
| (6) Man-Made Resources | NK | NK | 0 | NK | - | + | - | + | - | + | - | + | - | + | - | + |
| (7) Transportation (Intermodel) | | | | | | | | | | | | | | | | |
| (a) Navigation | 0 | - | 0 | - | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + |
| (b) Tug & Barge | 0 | + | 0 | + | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - |
| (c) Railroads | 0 | + | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | 0 | 0 | - | 0 | [illegible] |
| (d) Motor Carriers | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | [illegible] |
| (e) Construction Site | NK | NK | 0 | 0 | NK | NK | - | 0 | NK | NK | - | 0 | NK | NK | - | [illegible] |
| (8) Energy | NK | - | 0 | NK | - | + | - | 0 | - | + | - | 0 | - | + | - | [illegible] |
| (9) Business & Industry | 0 | - | 0 | 0 | + | + | + | 0/+ | + | + | + | 0/+ | + | + | + | 0/+ |
| (10) Recreation | | | | | | | | | | | | | | | | |

Table 3?- Summary of Effects of Plans (Cont'd)

| | Low Traffic Forecast Plans | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plan RX27 | | | | Plan RXI27 | | | | Plan RX30 | | | | Plan RXI30 | | | | Plan AVII27 | | | |
| | R | | L | | R | | L | | R | | L | | R | | L | | R | | L | |
| | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT |
| (a) Water Related (b) Boating | NK | NK | - | + | NK | NK | - | + | NK | NK | - | + | NK | NK | - | + | NK | NK | - | - |
| - Physical Damage (Reduced) | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | + | 0 | - | 0 | - |
| - Competition for Lock Transits (Reduced) | NK | NK | - | - | NK | NK | - | - | NK | NK | - | - | NK | NK | - | - | NK | NK | + | + |
| - Conflicts/Congestion on the River (Reduced) | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | - |
| - Fishing & Hunting | NK | NK | - | + | NK | NK | - | + | NK | NK | - | + | NK | NK | - | + | NK | NK | - | - |
| - Cross-Channel Transportation | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | + | NK | NK | 0 | - |
| (11) Agriculture (Displacement of Farms) | NK | NK | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 | 0 | 0 | 0 | 0 |
| (12) Public Facilities & Services | NK | + | - | 0 | NK | + | - | 0 | NK | + | - | 0 | NK | + | - | 0 | NK | + | - | 0 |
| (13) Property Value & Tax Revenues | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 |
| (14) Community Cohesion | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + |
| (15) Community & Regional Growth | 0 | + | - | + | 0 | + | - | + | 0 | + | - | + | 0 | + | - | + | 0 | + | - | + |
| (16) Institutional | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + |
| d. Cultural Resources | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK |

| | Low and High | | | | High Traffic Forecast Plans | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No-Action | | | | Plan AVII27 | | | | Plan AX27 | | | | Plan [illegible] | | | |
| | R | | L | | R | | L | | R | | L | | R | | | |
| | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | LT | ST | [illegible] | [illegible] | [illegible] |
| (a) Water Related (b) Boating | NK | NK | 0 | 0 | NK | NK | - | - | NK | NK | - | + | NK | NK | - | + |
| - Physical Damage (Reduced) | 0 | 0 | 0 | 0 | 0 | - | 0 | - | 0 | + | 0 | + | 0 | + | [illegible] | - |
| - Competition for Lock Transits (Reduced) | NK | NK | 0 | - | NK | NK | + | + | NK | NK | + | + | NK | NK | + | + |
| - Conflicts/Congestion on the River (Reduced) | NK | NK | 0 | 0 | NK | NK | 0 | - | NK | NK | 0 | + | NK | NK | - | + |
| - Fishing & Hunting | NK | NK | 0 | 0 | NK | NK | - | - | NK | NK | - | + | NK | NK | - | + |
| - Cross-Channel Transportation | NK | NK | 0 | 0 | NK | NK | 0 | - | NK | NK | 0 | + | NK | NK | 0 | + |
| (11) Agriculture (Displacement of Farms) | NK | NK | 0 | 0 | 0 | 0 | 0 | 0 | NK | NK | 0 | 0 | NK | NK | 0 | 0 |
| (12) Public Facilities & Services | NK | NK | 0 | 0 | NK | + | - | 0 | NK | + | - | 0 | NK | + | - | 0 |
| (13) Property Value & Tax Revenues | NK | NK | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 |
| (14) Community Cohesion | NK | NK | + | 0 | - | + | - | + | - | + | - | + | - | + | - | + |
| (15) Community & Regional Growth | 0 | - | 0 | 0 | 0 | + | - | + | 0 | + | - | + | 0 | + | - | + |
| (16) Institutional | - | 0 | - | 0 | - | + | - | + | - | + | - | + | - | + | - | + |
| d. Cultural Resources | 0 | 0 | 0 | 0 | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK |

Matrix Key

R = Regional Level - Great Lakes/St. Lawrence Seaway
L = Local Level - St. Lawrence River Area
ST = Short Term Impact
LT = Long Term Impact
+ = Beneficial
- = Adverse
0 = No Impact or Very Minor Impact +/-
A = Altered
NK = Impacts Not Known at this Stage

(1) Add nonstructural measures to maximum utility at that date.

NOTE: Reference appropriate appendices for detailed information

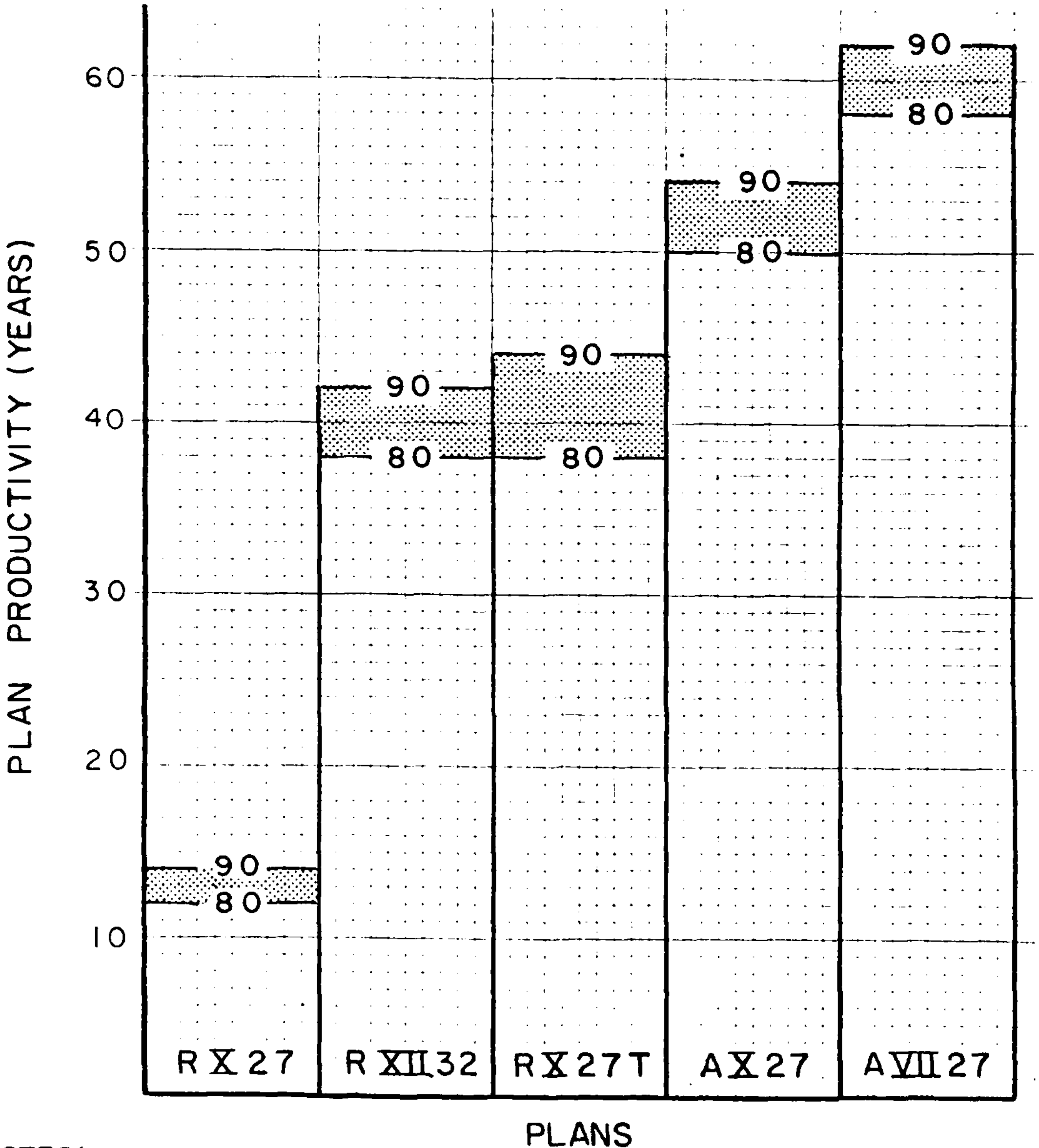
It should be noted that, similar to the "twin" parallel locks plan (AVII27) in the low forecast evaluation, the capacity model was not developed to directly examine Plans RX27T, and AX27. Again, lock service times were judgementally adjusted so that the capacity model would run to simulate the conditions expected to take place for these lock plans. Plan RX27T has the new replacement lock service times reduced, for Classes IV through VII only, by 30 percent. This figure was judgementally derived after observation of present and future fleet mix for other plans; acknowledgement of the inefficiencies in the locking process of two ships; and, realization that even at, or near capacity there may not always be two ships of the appropriate classes waiting to enter this lock from any one direction. Plan AVII27 was simulated as described and was explained in the previous section. Similar to Plan AVII27, Plan AX27 had the same lock service times for Classes IV through VII, but the lock service times for the larger ships (Classes VII, IX, and X) were not changed. Based upon judgement and the results of the analysis, it is felt that the productivity of the parallel "twin" locks (AVII27) may be somewhat overstated, while the productivity of the parallel Class X lock (AX27) may be slightly understated. The simulations presented in this report will be the subject of additional study in Stage III.

Similar to the process described for the low traffic forecast plans, additional tests were applied to the five plans for the high traffic forecast. Figure 32 shows a comparison of each plan's productivity. From observation of Figure 32 shows a comparison of each plan's productivity. From observation of the plan productivity, Plan RX27 was eliminated from further consideration. Again costs of the remaining four plans were developed so that the economic productivity of the plans could be compared. The costs of the four plans are shown in Table 34. Note that Plan AVII27 allows the existing system to reach capacity, followed by nonstructural improvements, and then followed by "twin" locks construction (which require additional operation and maintenance costs; the additional O and M for the parallel locks). The costs for the nonstructural improvements and the additional operations and maintenance of the parallel locks only, are included in the cost of Plan AVII27. For Plan AX27, only the additional operation and maintenance costs are added to the cost of the new locks and wider channels.

The economic productivity of the four plans is presented on Figure 33 for comparison. Because Plan RXII32 falls far short of the other three plans in this comparison, and because of the large environmental impacts associated with this plan it will be eliminated from further consideration. The remaining three plans: AVII27, AX27, and RX27T are fully tested in the remainder of this evaluation. Table 33 summarizes the effects of these three plans and compares them to the "No-Action" plan.

CANDIDATE EQ PLANS

The EQ evaluation considers impacts on ecological, cultural, and aesthetic attributes of significant natural and cultural resources. In evaluating the alternative plans for this study, the most significant EQ resource to be considered is the St. Lawrence River. The River encompasses all three of the aforementioned attributes and has been identified by the U.S. Fish and




NOTES:

1. ALL PLAN PRODUCTIVITIES SHOWN ARE FOR THE CONSTRAINING LOCK NODE (i.e. WELLAND CANAL).

90 80 2 THE SYMBOL SHOWS THE RANGE OF PLAN PRODUCTIVITY FOR THE 80 AND 90 PERCENT LOCK UTILIZATIONS TESTS.

FIGURE. 32 HIGH TRAFFIC FORECAST, PLAN PRODUCTIVITY

Table 34 - U.S. Costs of High Traffic Forecast Plans (St. Lawrence River)
Investment (1) Costs in Millions of Dollars (March 1982 Price Levels)

| Channel Depth (feet below LWD) / Lock Plan | Replace Existing System | | | | New Locks Plus Existing System | |
|---|---|---|---|---|---|---|
| | 115' W X 1,200' L Locks - Class X (2) | 115' W X 1,350' L Locks - Class XI | 145'W X 1,460' L Locks - Class XII | Tandem 115' W X 1,800' L Locks 2 - Class VII or 1 Class X | "Twin" 80' W X 860' L Locks - 2 Class VII | 115' W X 1,200' L Locks - 1 Class VII or 1 Class X |
| 27.0 (26.0 Draft) (6) | N.E. (3) | N.E. | N.E. | RX27T 1,192 | AVII27 362 (4) | AX27 1,104 (5) |
| 30.0 (28.0 Draft) (7) | N.E. | N.E. | N.E. | N.E. | N.E. | N.E. |
| 32.0 (30.0 Draft) (7) | N.E. | N.E. | RXII32 2,950 | N.E. | N.E. | N.E. |

(1) Total Investment Cost including both Federal and non-Federal First Costs.

(2) Vessel Size: Class VII - 75' W X 730' L; Class X - 105' W X 1,000' L; Class XI - 105' W X 1,100' L' and Class XII - 130' W X 1,200' L.

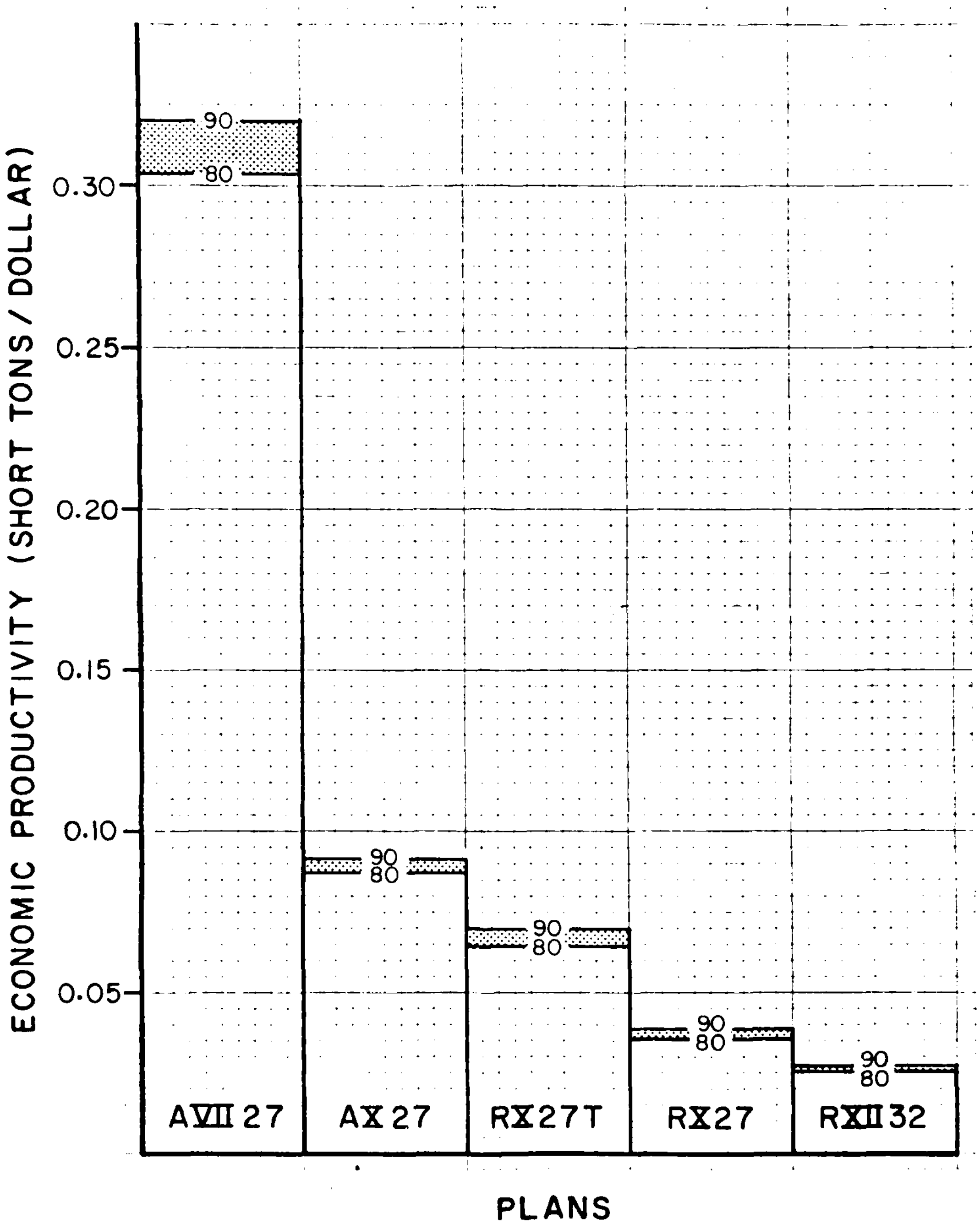
(3) N.E. - Not evaluated for this traffic forecast.

(4) Includes cost of nonstructural improvements and additional Operations and Maintenance.

(5) Includes additional Operations and Maintenance Costs.

(6) Design draft is 25.5 feet with seaway operating agency approved draft of 26.0 feet.

(7) Present channel design criteria recommends a 2-foot under keel clearance for any deepening plan.




NOTES:

1. ALL ECONOMIC PRODUCTIVITIES SHOWN ARE MEASURED AT THE CONSTRAINING LOCK NODE (i.e. THE WELLAND CANAL).
2. THE SYMBOL SHOWS THE RANGE OF PLAN ECONOMIC PRODUCTIVITIES FOR THE 80 AND 90 PERCENT LOCK UTILIZATION TESTS.

FIGURE. 33 HIGH TRAFFIC FORECAST: ECONOMIC PRODUCTIVITY OF PLANS

Wildlife Service, the New York State Department of Environmental Conservation, Save the River, and others as a significant resource.

In establishing critical criteria for the evaluation of EQ plans, any plan which adversely effects any of the three attributes - ecological, cultural, or aesthetic - of the St. Lawrence River would reduce its desireability of being selected as an EQ plan. Therefore, any plan which could adversely effect any of the established attributes was initially eliminated during this evaluation.

In evaluating the alternative plans (reference Impact Assessment and Evaluation Section for complete description), the only plans for either the low or high traffic forecasts that seem to cause no major modifications or disruptions (i.e., river dredging, widening, disposal, and channel modifications throughout many portions of the river) to the ecological and aesthetic attributes of the River are the nonstructural and structural portions of Plan AVII27 (low) and Plan AVII27 (high). Impacts to cultural resources cannot be reasonably predicted at this time. However, a cultural resource predictive model is currently being prepared and may be available during the summer of 1982.

Nonstructural measures would create the least significant impact on EQ resource attributes since they would only involve minor modifications at the existing lock sites; whereas the structural alternative, AVII27 (low and high forecast), would require the construction of two new low-lift locks at Massena, NY. Construction of AVII27 would disturb and/or destroy both aquatic and terrestrial habitat and species only in one specific localized area at the location of the existing locks, Massena, NY. The nonstructural plan could be a potential EQ plan, but it does not meet the overall study objectives and, therefore, is not implementable in itself. Plan AVII27, for both the low and high forecasts, could be considered as a potential candidate EQ plan.

Structural alternate Plans RX27 and AX27 require construction and dredging (i.e., channel widening) in the St. Lawrence River. This could be viewed as a negative adverse impact on the ecological and aesthetic attributes of the river resource, but would be temporary in nature. Both alternatives will eventually reduce vessel transits, which could be beneficial since the frequency of disturbances to the river environment caused by vessels would be reduced. However, the actual disturbance per occurrence could be of a greater magnitude, since larger class vessels will be navigating the system. Plan AVII27 allows for more transits of the existing type Class VII vessels, hence no ship size increase, and Plans RX 27 and AX 27 for fewer total transits, although some transits are of larger Class X vessels. Plans RX27 and AX27 do have more construction-related adverse impacts as compared to Plan AVII27. However, to adequately compare these alternatives at this stage of planning for determination of EQ benefits, additional information is required. This will have to be obtained in Stage 3 planning. Information on physical differences of hydrodynamic parameters of the larger class vessel (i.e., surge, drawdown, height of vessel generated wave), and the effects of larger propulsion systems as compared to existing Class VII vessels is not completely available and must be obtained. This information will help in

assessing if an increased number of Class VII vessel transits is less environmentally damaging than fewer vessel transits by larger Class X vessels. Therefore, the EQ evaluation for this report is only a partial and incomplete evaluation.

Based on current information and continued reassessments and reevaluations pertaining to plan formulation and the planning process, it is recommended that the following plans be considered as EQ candidate plans and be carried forth into Stage 3; nonstructural measures in combination with Plan AVII27 and RX27 for the low forecast, nonstructural measures in combination with Plan; and AVII27 and AX27 for the high traffic forecasts.

CANDIDATE NED PLAN

Several plans of improvement have been identified as comparable capacity expansion measures. The selection of the NED plan has been traditionally based upon the identification of a single candidate plan which satisfies all of the planning objectives and the evaluation criteria which also maximizes net annual benefits. A plan that fulfills this requirement is designated the NED plan.

The National Economic Development (NED) objective is described as a contribution to the national output of goods and services. Beneficial effects from a plan include the reductions in future economic resources which may be released for more productive uses elsewhere in the economy. Adverse effects are the opportunity costs of resources used in initial implementation, future operation and maintenance and external diseconomies.

Individual plans were formulated in light of two levels of expected traffic flows. Continued growth in bulk commodity movements could be accommodated by either replacement of the existing locks with a Class X lock size alternative or construction of duplicate Seaway locks (Class VII), which would supplement the existing lock facilities. Both candidate plans produce substantial net annual benefits, however, the twin-Seaway locks plan maximizes the net benefits criteria for NED plan selection under the low traffic scenario. Replacement locks similar in size to the existing Poe Lock would allow the systemwide movement of the present day design vessel (i.e., 1,000 foot X 105 foot) throughout the GL/SLS system. Twin Seaway size locks would require continued operation of existing locks which would be more than 90 years old (110 years plus for the Canadian locks) by the end of the current plan evaluation period.

Growth rates in excess of historical levels would require that future lock modifications be capable of accommodating significantly higher commodity flows. Construction of new Poe-size locks to supplement existing locks or construction of a duplicate lock system with dimensions similar to existing locks would be capable of responding to future levels of demand. Both alternatives would require continued operation of existing locks placed in operation in 1959.

A range of alternative lock sizes have been evaluated for this study. Only one alternative described above (i.e., twin Seaway locks) could accommodate

both levels of traffic. This plan could also service the majority of the current Great Lakes fleet. This plan and the replacement plan with Poe-size locks have similar levels of net annual benefits for the low traffic scenario. Both plans also reflect the range of alternate ship sizes now in operation. Therefore, each plan was identified as the NED candidate plan for the low traffic scenario. A third alternative which would result in a parallel lock system of Poe-size and existing locks is also responsive to the high traffic scenario and offers substantial net benefits. This plan physically accommodates all present ship sizes and was designated as the second NED candidate plan for the high traffic scenario.

Although modifications to be made at the Welland Canal by Canadian navigation interests will ultimately dictate the future lock dimensions of the St. Lawerence River locks, all candidate NED plans identified above are considered to be compatible with the most reasonable Canadian action to be initiated at the Welland Canal and are economically feasible U.S. investments.

Implementation of the replacement locks alternative (RX27) would allow the existing locks to be phased out following lock construction activities. This alternative would physically accommodate all current vessel sizes in the U.S. and Canadian fleets. Fluctuations in the level of traffic over the planning period could be met under this plan by reactivating the original locks presently in service. Operating procedures could be implemented which would allow use of existing locks during seasonal traffic peaks or allocate less than maximum size vessels to the smaller locks which could be operated in parallel. This would keep the operation and maintenance costs for the systems to the lowest possible level.

Use of the current system maximum vessel size (1,000 foot X 105 foot) throughout the upper and lower lakes could also occur under this alternative. This condition would allow 1,000-foot vessels, which are owned and operated by U.S. interests, to effectively participate in the major dry bulk trades.

Increased numbers of these vessel sizes would be required if this plan were implemented. United States shipyards, which have constructed 13 maximum-size vessels, could compete for future construction contracts. The related regional economic impacts would be positive for Great Lakes shipbuilding activity.

A plan which replaces the existing Seaway-size locks with lock chambers to accommodate a maximum size of 1,000-foot X 105-foot (Plan RX27) will be identified as the NED plan for the low traffic forecast. Its counterpart for the high traffic forecast will be Plan AX27, which keeps the existing locks in operation along with the new Poe-sized locks. This plan should be further investigated in Stage 3 and coordinated with study participants for review and comment. The economic feasibility of this alternative has been documented in this report and related appendices. This plan meets all evaluation criteria.

## ALTERNATIVE PLANS

The alternative plans for which future study is proposed are a combination of both the EQ and NED candidate plans.

Plan AVII27 had high NED potential at both the low and high traffic forecasts, and minimized environmental damage, especially in the case of the low traffic forecast. Plans RX27 and AX27 are very similar in that Class X locks are built, and either operated as a replacement to the existing locks or in addition to them. The Class X lock plans have high NED potential, and they would minimize the potential impacts of any larger lock size plan. No deepening is proposed for any of the plans recommended to further study. However, dredging in the St. Lawrence River would be required to widen channels for any increase in maximum vessel size permitted by larger locks.

There are really only two distinct alternative plans:

- Build additional Seaway-sized locks, or
- Build larger Class X locks.

In the case of the Seaway-sized locks, all four locks would have to be operated to process the forecasted tonnage (for both low and high forecasts). For the larger locks, they could be operated independent of the existing locks (mothball the existing locks) for the low traffic forecast. If and when the high forecast tonnage projections were to materialize, these "mothballed" Class VII locks could be opened up and utilized to carry the extra tonnage/transits. The flexibility of these plans was another significant consideration for the selection of these plans for further study.

In summary, consideration has been given to all plans in the assessment and evaluation process. Following that, further consideration was given to both the EQ and the NED plans. The resulting plans recommended for further study are shown in the following table.

Table 35 - Plans Recommended for Further Study

| Traffic Forecast | Alternate Plans |
|---|---|
| Low | AVII27, RX27 |
| High | AVII27, AX27 |

## COST APPORTIONMENT

a. U.S. Project Cost Apportionment.

The plans recommended for further study - AVII27, RX27, and AX27 - provide benefits to commercial navigation. Therefore, under existing regulations, any costs associated with dredging of the navigation channels and

transporting of dredged materials to disposal facilities will be borne by the Federal Government.

Those costs associated with the construction of confined disposal sites, including providing lands, easements, and rights-of-way, will be borne by the local sponsor(s).

The State(s) would contribute 5 percent of the construction cost in accordance with previously proposed cost-sharing policy. On 15 July 1981, the Department of the Army, on behalf of the Administration, transmitted proposed legislation to Congress that would provide for full recovery of certain operation, maintenance, and construction or rehabilitation costs for deep draft channels and ports with authorized depths greater than 14 feet. If this legislation is enacted, Corps of Engineers expenditures for a project would be subject to recovery as provided in the proposed legislation. Accordingly, non-Federal interests would be required to reimburse the Federal Government for construction of navigation features of the recommended plan, and all subsequent expenditures for operation, maintenance and rehabilitation; except for expenditures assigned by the Secretary of the Army to Governmental vessels in noncommercial service. The proposal to fully recover these costs supersedes the previous requirement for a 5 percent State cash contribution.

The entire amount of the Federal construction or rehabilitation expenditures to be reimbursed, including interest during construction and interest on the unpaid balance, would be reimbursed within the life of the project, but in no event to exceed 50 years after the date the project becomes available for use. The interest rate for reimbursement purposes would be determined by the Secretary of the Treasury based on the average market yields on outstanding obligations of the Untied States. Reimbursements for operation and maintenance would be made annually, and may be scheduled and periodically adjusted to result in the payment of actual operation and maintenance costs. The non-Federal public body would be authorized to recover its reimbursement obligations pursuant to this requirement by the collection of fees for the use of the project by vessels in commercial waterway transportation.

b. International Project Cost Apportionment.

This report has only looked at one International cost apportionment assumption. That being, each country pays for the necessary improvements within its territorial boundaries. As additional data is developed another breakdown will be presented in the final version of this report. This second cost apportionment scenario will be based on a 50-50 split of improvements costs for facilities in the St. Lawrence River. The 50-percent split of total St. Lawrence River costs applied to the U.S. will be divided into potential U.S. benefits. This will help to determine whether or not the U.S. would have an interest in the proposed project if such a cost apportionment assumption was proposed by the Canadians.

c. Existing Project Cost Apportionment.

The St. Lawrence Seaway navigation project is, at present, the only U. S.-maintained waterway project which is required to collect user fees to offset construction, and operations and maintenance costs. The St. Lawrence Seaway Development Corporation operates and maintains the navigation project, and reimburses project costs to the U. S. Treasury on a scheduled basis from the tolls it collects. In its present configuration, the seaway would presumably be in compliance with the pending legislation.

The International cost apportionment of the existing project strictly follows territorial boundaries. That is to say, the U. S. paid for all improvements within U. S. territorial boundaries, and Canada paid for those improvements in Canada.

LOCAL SPONSOR

A local sponsor is required for any new navigation project implementation. The duties of that sponsor are outlined in earlier paragraphs. For the existing project, the St. Lawrence Seaway Development Corporation is performing these duties.

The St. Lawrence Seaway Development Corporation has indicated they would be willing to act as the "local sponsor" and responsible operating agency for any proposed project. The legal aspects of local sponsorship will be investigated during Stage 3 studies, as the proposed legislation specifies a "non-Federal interest" as the local sponsor.

## STUDY MANAGEMENT

### STUDY TEAM

The District Engineer, Buffalo District Corps of Engineers, is responsible for the conduct and management of the St. Lawrence Seaway Additional Locks Study. A Study Team within Buffalo District is drawn from the Study Management, Economics, and Environmental Sections of the Planning Division, Design and Hydraulics Branch in the Engineering Division, and the Public Affairs Office. The Study Team consists of a study manager, an economist, an environmentalist, a sociologist, a designer, and a public involvement specialist. Additional expertise from other units of the District will be assigned to the study and utilized on an "as needed basis." Appropriate augmentation will be provided through retention of outside consultants. A direct liaison of the working level will be maintained with the agencies and organizations and interested citizenry during the course of the study to obtain their input. Under an agreement between the Corps of Engineers and the U.S. Fish and Wildlife Service, the latter agency is responsible for furnishing planning aid documents at timely intervals throughout the study and for formal review of the study results.

### PUBLIC INVOLVEMENT

It is the policy of the Corps of Engineers that civil works projects under the authority of the Corps be conducted in an atmosphere of public understanding, trust, and mutual cooperation. This is accomplished through actively involving the public in water resources studies by opening and maintaining channels of communication.

The process of identifying water resources issues, exploring alternatives, and selecting a feasible and desirable plan requires a continuous two-way communication process between the study planners and identifiable publics - public officials, public and private groups, and the study area citizenry. The main goal of a public involvement program is to establish this two-way communication process which will:

. Acquire sufficient information from the broadest practical cross section of concerned citizens, groups and Governmental agencies to identify area problems, issues, needs, priorities, and preferences regarding alternative resource usage, development, and management strategies;

. Inform the public and promote full public understanding of the St. Lawrence Seaway Additional Locks Study - the study process, progress, implication, and results;

. Develop a process of interaction; and

. Instill in the public a desire to participate and become involved in the study.

The Final Feasibility Report is the last planning phase and is concerned with the detailed development of a limited number of plans, their assessment, modification, and evaluation leading to the recommendation of one plan. The focus of the planning effort shifts from plan formulation to impact assessment and evaluation. Similarly, the nature and intensity of the pblic involvement effort changes because each alternate plan can be described in very real terms. The features of the alternate plans are defined, and the public can begin to visualize or assess the potential impacts and affects of the proposed plans in their area(s) of concern. The public involvement program, measured in terms of numbers of participants and diversity of interest groups, will, therefore, be greatest and broadest during this final stage of the planning process.

Deatiled information on the nature, magnitude, and incidence of the effects of the alternatives and an assessment of the evaluation of those effects will be completed. Modification of the alternatives to eliminate or mitigate adverse effects and attempts to negotiate compromises and tradeoffs in order to develop support for the decisions to be made will be necessary. To accomplish this, information will have to be obtained from the public on remaining issues that have not been fully addressed, on effects which the public perceives might have been overlooked, the adequacy of the assessment of effects, on the acceptability of certain effects, on the potential compromises and trade-offs that might be acceptable, and on indications of preferences for various alternatives. To supply this information, the public will be furnished detailed descriptions of each alternative, the nature, magnitude and incidence of the effects, the feasible modifications which are available to eliminate or mitigate adverse effects, and the principal criteria that will be used to select the perferred plan for recommendation.

## INVOLVEMENT OBJECTIVES

The primary objective of the public involvement program is to provide forums in which interested and affected publics can obtain detailed information concerning the implications of each alternative; contribute information useful in determining the short and long-term consequences and incidence of effects; suggest mitigation measures and modifications which would increase the acceptability of alternatives, and express preferences with regard to different alternatives.

The relevant publics during development of the Final Feasibility Report are the broadest of any planning stage. All directly affected individuals and concerned interest groups would be invited to participate. Emphasis will be given to those segments of the public likely to bear significant costs and interest groups who are perceived to be sufficiently interested in the final recommendations to use other means to influence decisions.

Involvement requires intensive and regular interaction among various interests as well as between the public and the Corps. There are several appropriate forums. Early in development of the Final Feasibility Report, moderate-sized meetings such as workshops would be effective. During the latter phases of the stage, when the impact assessment is substantially

completed and when the major conflicting interests can be identified, small meetings for the purpose of negotiation could be critical.

CANADIAN COORDINATION

The St. Lawrence Seaway is an international waterway, the majority of which lies solely within Canadian territory. It should also be noted that the U.S. portion of the Seaway - the Snell and Eisenhower locks and the Wiley-Dondero Canal - lies between two sections of Canadian improvements; four locks downstream and one lock upstream on the Lake Ontario-Montreal section and the entire Welland Canal section consisting of eight locks. It goes without saying that the improvements to the St. Lawrence Seaway in U.S. territory must be accompanied by compatible improvements to the Canadian sections. Thus, coordination with Canada throughout the study is paramount. This feasibility study, the first of two phases of study, will look at improvements to the entire St. Lawrence Seaway to determine from a U.S. standpoint whether improvements are engineeringly, economically, and environmentally feasible and whether there is a Federal interest in their development. If improvements are found warranted, a second phase of study will be sought. The first phase, this U.S. feasibility study, includes informal coordination with Canada through the Seaway entities (i.e., SLSDC/SLSA). The second phase, a joint study (following this feasibility study), would require formal coordination with Canada. The first phase will encompass exchange of data and information, unofficial attendance at meetings, review of study documents, and input of Canadian publics into a public involvement program. The second stage is expected to include full coordination between the two countries. This second stage is not presently part of the Corps planning process, and it would require additional authorization.

Due to diplomatic protocal, all coordination with Canadian agencies (except that between the two Seaway entities, SLSDC/SLSA), and publics must be approved by the U.S. State Department and the Canadian Ministry of External Affairs. In its letter of 11 April 1978, the Canadian Embassy indicated the willingness of Canada to participate informally in the SLSAL and GLCCH studies. This participation will be accomplished through the St. Lawrence Seaway Authority for the SLSAL study and the Canadian Coast Guard for the GLCCH study. The Ministry of External Affairs will keep provincial authorities informed about the studies. This was the limit of coordination involved in studies to date.

The need for protocal and informal nature of present coordination has limited the investigations presented in this report. Therefore, it will be a recommendation of this report, that the results of this report be formally coordinated with the Canadian Government through the U.S. State Department. The purpose of this formal coordination is to determine where the Canadians are in their planning efforts of improvements at the Welland Canal, and obtain their comments on the results of the Preliminary Feasibility Report. If they have studies underway, or proposed in the near future, the U.S. Government may want to consider some type of joint study or increase cooperation beyond the informal information exchange policy presently being utilized. This is critical to any Final Feasibility Report level effort undertaken for this study because of the nature of the recommended plans. If, for example, Final

Feasibility Studies could be concentrated on either the EQ Plans (new locks at present Seaway size or new larger locks) or NED Plan (new larger locks), the process would be far more productive and conclusive. From the best information available in the Preliminary Feasibility Report, it looks like the Canadians are considering larger locks (at least Poe-sized) at the Welland Canal. However, without any formal confirmation of this position, the U.S. would have to investigate both plans at present Seaway size and also new larger locks at the same level of detail.

## STUDY SCHEDULE

The tentative schedule for completion of this feasibility study has been developed and is shown below. However, it is presently being coordinated and subject to revision. The final schedule will be established and published after completion of the Canadian coordination efforts and budgeting of study funds. The tentative milestone dates correspond to the following tasks:

| Milestone | Date | Task Title |
|---|---|---|
| MS 6 | May 1985 | Submission of draft Final Feasibility Report to Division |
| MS 7 | June 1985 | Final Feasibility Study Issues Resolution Conference |
| MS 8 | July 1985 | Completion of Action on Conference Memorandum for Record |
| MS 9 | September 1985 | Coordination of Draft Final Feasibility Report and Draft Environmental Impact Statement |
| MS 10 | January 1986 | Submission of Final Feasibility Report and Revised Draft Environmental Impact Statement to Division |
| MS 11 | March 1986 | Release of Division Engineer Public Notice and Submission of Report to the Board of Engineers for Rivers and Harbors (U. S. Army Corps of Engineers) to initiate Washington level review. |

## CONCLUSIONS

The conclusion of this report is that the most feasible alternatives for augmenting the capacity of the U.S. locks in the St. Lawrence River involve construction of additional or replacement locks in concert with Canadian plans of improvement at the Welland Canal and the remaining St. Lawrence River locks.

Two types of plans are considered to be equally technically, economically, environmentally, socioeconomically, and institutionally feasible based on their overall evaluation during preparation of the Preliminary Feasibility Report.

The first plan involves duplication of the existing Seaway-size locks throughout the lower system. This plan would involve a sequence of events leading to a completely duplicate system. The sequence of events is as follows:

a. The Welland Canal reaches its capacity after all nonstructural alternatives have been utilized to their fullest extent.

b. Duplicate locks are built at the Welland Canal along a new alignment.

c. The locks in the St. Lawrence River are improved with nonstructural improvements to maximum utility when their initial capacity is reached.

d. The St. Lawrence River locks are duplicated along a new adjacent alignment.

This plan is the least environmentally damaging, has net benefits approaching that of the other recommended plans, and can pass both traffic forecasts used in this study. Its biggest drawback is that it does not utilize the maximum vessel size in operation on the Great Lakes today. This results in incompatibility for the system as a whole, and does not take advantage of the potential economies of scale of a larger vessel size.

The second plan involves construction of "Poe-sized" (Class X) locks throughout the lower system. These new larger locks could be used to augment the existing locks or operate by themselves with the Seaway-sized locks held in reserve (in the event of high traffic growth they could be placed back into operation). This plan would have a simplified sequence of events, in that any improvement involving larger locks in the lower system must take place at the same time for the lower system to achieve compatibility. This plan is more environmentally damaging than the first because some dredging is required to widen the navigation channel for larger ships, but has higher net benefits. It also takes advantage of the economies of scale from using larger vessels which may stimulate additional Great Lakes regional development.

Both of these plans will be carried into Final Feasibility Studies for a more thorough analysis and comparison.

It is concluded that continued availability and future improvement of the cost effective and energy efficient transportation resource available in the St. Lawrence Seaway is in the national interest.

All U.S. plans for Seaway improvement require comparable Canadian improvements, therefore, formal coordination must be initiated as early in this study as possible and continue throughout the study.

Further, it is concluded that improvements considering locks larger than Poe-sized (Class X) or deepening of channels beyond the present authorized depth is not economically justified based strictly upon navigation benefits.

## RECOMMENDATIONS

It is recommended that the Buffalo District proceed with additional investigations and prepare a Final Feasibility Report and Final Environmental Impact Statement for the St. Lawrence Seaway Additional Locks Study.

It is recommended that at the beginning of Final Feasibility studies, further attempts be made to solicit the U.S. State Department to approach the Canadian Government for a formal review of the results of this Preliminary Feasibility Report with a view toward obtaining: their comments on the report; their position on the conclusions herein; and the present status and direction of any studies they may have underway at present or will have underway in the near future on the Welland Canal and remainder of the Seaway.

It is further recommended that Final Feasibility studies be limited to a maximum ship size of Class X, and that navigation channel deepening scenarios be eliminated from further study unless a multipurpose planning (including benefits to hydropower, lake regulation, and flood control) approach is utilized in such a study.

The full scope of the recommended plans (both nonstructural and structural), and their impacts should be addressed in the Final Feasibility Report. Modifications can and will be made at any time more information is available from Canada regarding their proposed plans of improvement for the Welland Canal and remaining St. Lawrence River locks.

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